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CIVIC CENTERS AND THE GROUPING OF PUBLIC BUILDINGS, WITH A SUGGESTION FOR BOSTON.

BY STEPHEN CHILD, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Society, November 20, 1907.]

THERE are on every hand cheering forecasts that a brighter day is dawning upon our American city life; that the fierceness of the rush and drive of the commercial whirlwind through which, as a nation, we have been passing, is somewhat abating, and though black and angry clouds lower upon the horizon, they are being broken up and dispersed by the bright sunshine of a more rational, a more peaceful and a more wholesome life, a life in which a more brotherly and neighborly feeling is growing, and in which all uplifting, moral and esthetic influences are having better opportunities for growth and development. While nothing can permanently darken or defer this brighter day to which we look forward, we may, by ill-considered and selfish actions, retard its progress. On the other hand, there are many influences over which we have direct control which may greatly hasten its arrival. Perhaps not the least helpful of these beneficent influences is the comparatively recent movement for a better civic art, better buildings both public and private; more numerous open spaces, adorned not only with flowers, shrubs and trees, but more frequently with fountains and other objects of art, such as properly located statuary, designed in an appropriate and dignified manner. The uplifting and inspiring influence of such artistic surroundings upon the community is very great, and they should be still further increased.

Much of the trend of civic improvement of late has been outward in ever-increasing circles, due largely to the wonderful development during the past twenty years in improved methods of rapid transit. Fearing that in this rapid growth we should be deprived of all our beauty spots, we have (and with reason here in Boston) been making great efforts and expending great sums of money to secure and develop large rural parks and scenic reservations, and to provide suitable parkway and boulevard approaches and connecting links for this great system. Far be it from me to decry the value of all this. On the contrary, I believe our city and metropolitan officials are to be congratulated upon the foresight and good judgment they have shown in securing and developing these most delightful features of our city, and that as time goes on it will be shown that they have proved of inestimable value to the health and morals of our community. Such features add to our fame and tend to attract not only visitors, but permanent residents of great value.

Possibly, however, we have gone far enough in this direction, for a time at least, and it may well be that a bit of introspection will do us good. May it not be that we need to study and reorganize the plan of the older and more thickly settled portions of our city with a view to securing more open spaces, and wider and more direct means of communication in the crowded portions of the city? Certainly in this study the grouping of needed public and semi-public buildings into so-called civic centers should be carefully considered.

The demand for a finer expression of civic art, especially in connection with our public buildings, is immediately confronted by the loss in dignity due to their widely separated locations, and it is becoming more and more evident that if such buildings can be grouped about a plaza or along a wide mall-like avenue in such a way that each building takes its proper place in harmonious architectural relation with other members of the group, each is enhanced in dignity and value. It has been asserted by a prominent architect that " isolated buildings of whatever individual merit are insignificant in comparison to massed constructions, even if these latter be comparatively mediocre in quality." It is evident that really fine buildings may be robbed of much of their impressiveness by being poorly located, crowded in among skyscrapers or more inferior buildings in such a way as to give little opportunity of seeing them, and almost no chance to appreciate their beauty. If beautiful buildings could only be grouped about a square or suitably pro-

portioned open space, how much more would they be admired and appreciated, and what a welcome addition would be made to our civic pride, now for many reasons almost extinct. I believe a finer public spirit would be aroused, and who shall say that as a result of this sort of publicity there might not be less of the corruption and so-called "graft" that now has such a good opportunity to flourish in our secluded and ill-placed public buildings? Nobody cares to go near them, and they are either so ugly or so inaccessible that many an intelligent, progressive citizen scarcely knows where they are, and never visits them unless he has to. Whereas if they were attractive and well-placed they would be more frequently inspected, and the "grafter" would feel that he was being more carefully watched than at present. Then, too, there is the great utilitarian gain in convenience if public buildings are grouped thus into administrative or civic centers, and a valuable saving in time for those having to transact public business by having them so massed.

I trust it will be interesting and profitable to study together for a few moments this evening what has been done in these respects in some European and American cities. The movement in this direction embraces most of the progressive municipalities of the civilized world, and, profiting by the mistakes of some of the older European cities, we here in America have been able to prepare plans, some of which are now in process of execution, which are distinct improvements over anything heretofore executed, except perhaps those at Paris and Vienna, and will make some of our American cities unrivaled in this respect.

Following a brief review of the more important of these developments, I will ask you to consider with me a suggestion in this respect for Boston, which I trust will interest you, as at least one of the many possible opportunities of making our city more dignified, impressive and inspiring.

While the movement toward securing civic centers and properly grouped public buildings is now receiving such well-deserved attention, and is sometimes spoken of as a new movement in civic life, it might more properly be referred to as a renaissance, for early historical research in the architectural development of cities shows us that such matters were very carefully considered in ancient times. Many of the celebrated early Egyptian communities show examples of this grouping, and in some instances the open spaces were embellished, as we know, with obelisks and other monuments. In some of these squares, or plazas, the shadow of the obelisk in the center marked the

passing hours upon the pavement, a suggestion worthy of our notice in the present day. In Assyria and Persia there are evidences that the grouping of palaces and temples was considered in very early times. But while we have some knowledge of these matters, the result of painstaking efforts of archeological students in Egyptian and Assyrian art, perhaps the most noted and certainly the most impressively dignified civic center of antiquity was the Acropolis at Athens.

In the prosperous days of Greece, when Athens was at the height of its power, civic pride and public devotion to public interests were very marked, and culminated in the notable aggregation of splendid structures grouped upon this noble hill. Even the ruins that have come down to us are magnificent. How much more so must have been the spectacle presented in the days of Pericles when every column was intact, every pediment and statue stood perfect and unmarred, the whole scene enhanced and made more beautiful by the brilliant atmosphere, Each building was nobly planned, not for itself alone, but in its relation to others of the group. What an impressive and inspiring sight it must have been, perhaps never excelled, and certainly an ideal toward which to strive.

The Greek genius was essentially and peculiarly artistic; that of Rome more especially political and administrative in its character. Rome conquered, administered and civilized the world of its time, founded modern civilization in fact, and while perhaps not creating a new art, developed and enriched other arts. The city of Rome became the center of all this administrative genius, and here about its Forum was built another grand civic center entirely different from that at Athens, but in its way equally impressive. Both the Acropolis at Athens and the Roman Forum afforded the people of these cities opportunty to mingle together, sharing their thoughts, their joys and their griefs. Here matters of the common weal were discussed and a broader public spirit developed.

After the decline of Greek and Roman influence, and during the so-called Dark Ages, little thought was given to any of these matters. Medieval cities were closely crowded communities, usually surrounded by fortified walls for the protection of the people from the attacks of wandering bands and neighboring feudal barons. Civic conditions were anything but attractive in these times. Streets were mere lanes, neither paved nor sewered. There were in most of these towns, market-places, however, and thanks to this provision, such communities now

possess an open square which has in more recent times been cleared of its booths and wagons, and embellished with planting, fountains and statuary, often making of it a most impressive and beautiful feature of the town's life. This development of the market-place has, however, come as a much later step. In medieval times these places were not cared for or improved, and there was no particular effort to group about them important public buildings, although the town-house and a church may have been built facing them. The great Gothic cathedrals suffered frequently from not being properly located and from being closely surrounded by low and unsightly buildings which mar the general appearance of these structures and prevent one's getting any adequate comprehension of their grandeur.

As warrings ceased and more peaceful times appeared, the towns and cities of Europe began to overflow the confines of their fortified walls and to spread out into the surrounding country. We shall see how the space occupied by these walls or bulwarks was later seized upon and utilized for great public improvements, for boulevards and civic centers, in Paris and other cities. In Vienna such space was developed into the magnificent Ringstrasse so-called, of which we shall hear more later. Let us look now at some of these civic improvements. Many of the views shown will no doubt be familiar to you, but I have endeavored to bring together the more important ones, and such as would have a bearing upon our problem here in Boston. Right here let me express my thanks to Professor Chandler, of the Architectural Department of Massachusetts Institute of Technology, and to Professor Pray, of the Lawrence Scientific School, and Mr. Fleischner, of the Boston Public Library, through whose courtesy I have been able to secure the lantern slides which I shall now be able to throw upon the screen. It may be interesting to turn back for a moment to Athens and Rome, to whose Acropolis and Forum I have already alluded.*

In no city in the world, perhaps, have better results been secured in this matter of the proper placing of buildings than in Paris. Here the public and semi-public buildings are almost always so placed or grouped as to enhance the appearance of one another and to provide pleasing vistas terminating the magnificent avenues. Perhaps the best and most famous example is the Louvre and Tuileries Garden. The Louvre is a civic center in itself. It is nearly 0.5 mile long and 0.25 mile

*Views of the Acropolis at Athens, and of Rome and the Roman Forum were here shown and commented upon.

broad. Part of this structure dates back to the sixteenth century, and the whole group contains some ten museums, besides the Ministry of Finance and that of Colonial Affairs. Many architects and sculptors have contributed to this harmonious group, which is generally considered one of the best works of French architecture.

Passing west of the Tuileries Garden, we come to the magnificent Place de la Concorde, one of the finest instances of plaza treatment in the world. From this the magnificent avenue of the Champs Elysées stretches westward, and a short distance in this direction we come to the modern civic center, where are grouped the Petit Palais and Grand Palais, two graceful buildings which are the permanent contribution of the Exposition of 1900. The avenue between these two palaces leads to the Alexander III Bridge, also a beautiful reminder of the same exposition. Returning to the Louvre, and just north of it, we find another civic center. Here are grouped the Ministry of Finance, the French Theater, and the Palais Royal, now used by the Council of State. Nearby is the Place de la République; also the Palace of Justice.

These are only a few illustrations of the way such matters are studied in this perhaps the most beautiful of modern cities, and no mention can here be made of the magnificent avenues, boulevards and parks.

The whole subject of civic art in Paris is placed in the hands of experts, and with the tireless energy of the French nation no such thought as that of standing still is ever considered. Progress toward better things is continuous. Every year sees plans for civic improvements made, which perhaps may be years in their execution, but which are all carefully studied, and when the need arises are ready for use. In this way few mistakes are made.

Next to Paris and, in fact, vying with it, if not in some respects excelling it in the grandeur of its civic improvements, is Vienna. Here the great space occupied by fortresses with their enclosing walls, and the open spaces formerly reserved for military drill grounds, becoming as they did, about the middle of the past century, not only of no avail for the original purposes for which they had been occupied, but a hindrance to the growth and development of the city, were, through the far-sighted and progressive good judgment of Emperor Francis Joseph, converted to the nobler purposes of magnificent civic improvements. The area formerly devoted to these warlike devices was so great,

and their value for many purposes so enormous (for they were situated in what was then near the center of the great city, and is now, in fact, well within what may be termed the heart of Vienna) that we may well imagine there was much discussion and no small contest over their ownership. The City of Vienna, the Kingdom of Austria, and the Crown Family itself, each laid claim to this territory, and as a result of this three-cornered contest the whole tract was set aside for the public's benefit; a portion of it that had been occupied by the old city wall was converted into a beautiful, broad, tree-lined boulevard or Ringstrasse, so-called; another portion was developed into parks just off from this boulevard, and forming magnificent foregrounds and settings for needed public buildings. The area to be utilized was so great that still another portion of it was reserved and under careful restrictions sold to furnish funds for building magnificent buildings and providing for their embellishment with suitable statuary, and so on.

We notice how the location of each building is carefully arranged so as to furnish an open space on at least one or more sides, so that its beautiful façades may be properly appreciated. We notice, too, the care with which buildings and monuments have been placed at vista points of the carefully-designed walks, streets and intersecting boulevards. Imagine the great and uplifting inspiration to the daily throngs of people passing and repassing these notable structures. What is particularly to be remembered is that these splendid effects have not been the result of chance, but have been brought about through the execution of most carefully thought-out plans, made with remarkable foresight some fifty years ago, and adhered to with a steadfastness of purpose greatly to the credit of the people of the Austrian capital. Would that some such steadfastness might inspire the law-makers of our own nation at Washington to adhere to and gradually and consistently carry out the magnificent scheme for civic improvement first planned by L'Enfant, Washington and Jefferson, over one hundred years ago, and now so happily revived and forming the inspiration for the plans of the so-called Burnham Commission. But more of this later.

Let us turn now for a brief inspection of what has been accomplished at Berlin. Probably the most famous single avenue of all Europe is that known by the name of Unter den Linden. The historic, patriotic and artistic sentiments of the entire German nation are centered here, and it is a civic center of great impressiveness. At the westerly end is the magnificent

Thiergarten, a fine public park of some 200 acres in extent, with its wonderfully impressive Sieges Allee, a beautiful feature. There are grand old trees, beautiful lakes and many other delightful objects of interest. Near here is the Brandenburg Gate.

At the easterly end of the avenue is the Spree Island, the older part of the city. (See Fig. 1.)* Here is an impressive group, including the Royal Palace and the Old Museum well placed about the open square known as the Lustgarten. Other beautiful buildings are grouped to the north of this, the whole island in fact being given up to public buildings, well-placed before open spaces, the latter parked and furnished with beautiful statuary, fountains and other embellishments. A rather modest bridge, but one well adorned with sculpture, spans the Spree and connects the island with the more modern city, and here the famous avenue Unter den Linden may be said to begin. On both sides for over two miles and a half are massive buildings, many of which are fine, and while some are of mediocre character, yet all are so skillfully grouped and interspersed with small parks like the Opern-Platz that the effect is one of dignity and repose. How much more impressive is this arrangement than if these buildings were scattered about the great city as is done in America, with no such effort to make each building serve its part in adding to the attractiveness of the others. May we not have our "Unter den Ulmus" here in Boston? I think we have the opportunity. One can well imagine with what watchful care any building proposed for this avenue is restricted, the emperor himself being given the authority to veto plans that do not come up to his high standards of beauty and symmetry.†

Let us now turn from European examples and look at what awakening America is doing in these respects. I think we shall be surprised, upon looking into this movement, to see what extent it has attained, and our self-complaisance here in Boston may be slightly shocked, perhaps to our advantage, when we see how our neighbors are improving their opportunities and we

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* For Figures 1–4, acknowledgment is due to the *Municipal Journal*.

† Several other views of Berlin public buildings were here shown and these were followed by views of the Kremlin at Moscow; the Nicolas Bridge and Square at St. Petersburg; St. Mark's Square at Venice; the Grand Palace and Gothic Hotel de Ville at Brussels; the spacious Zwinger at Dresden; the railroad station and square at Cologne; Trafalgar Square and the Thames embankment at London; also a plan of the new Kingshighway improvement there, — all illustrating interesting features bearing upon our own problems in Boston.

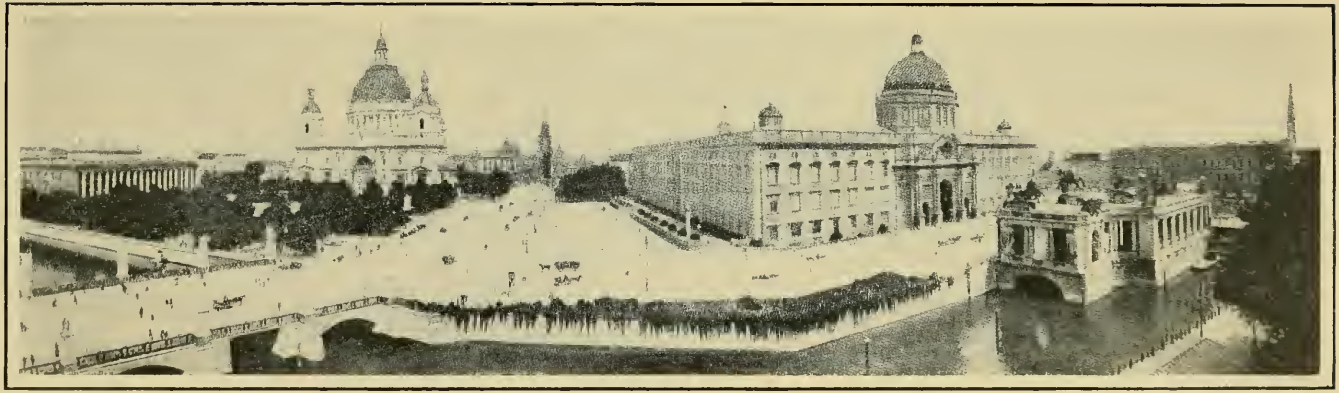


Fig. 1. A Civic Center at Berlin.

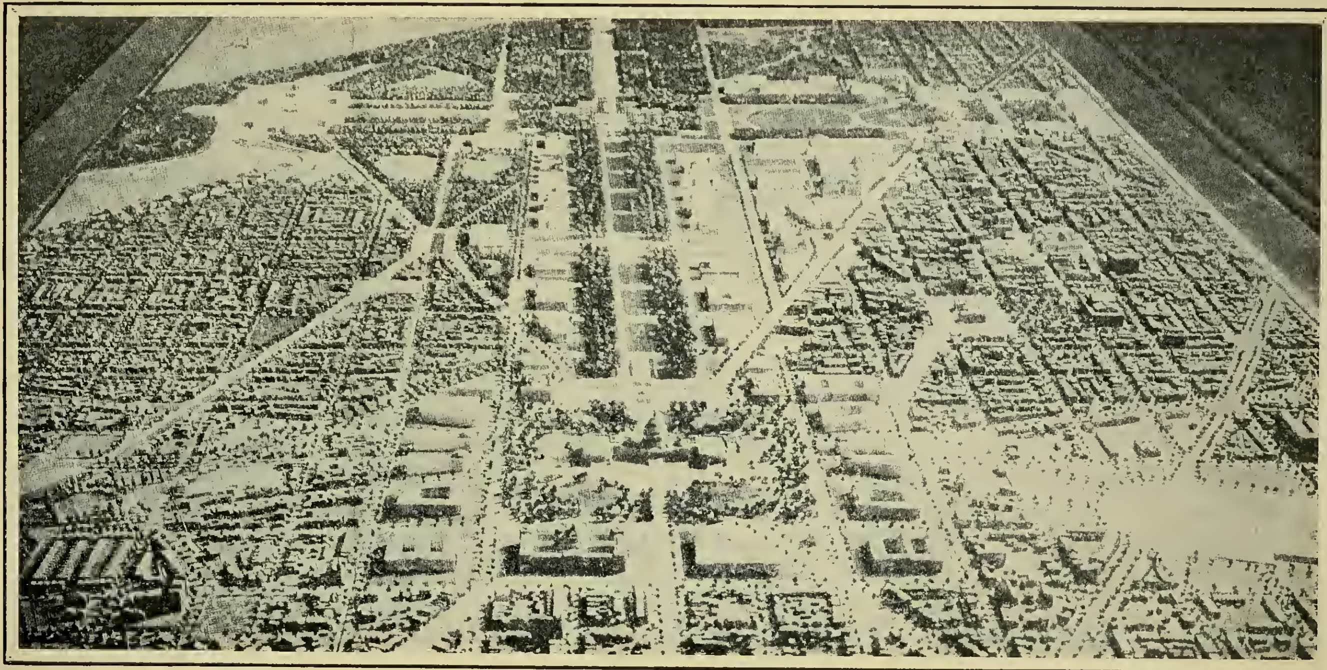


Fig. 2. Plan proposed for grouping Public Buildings at the National Capital.

are calmly letting ours slip by. Perhaps no one event has had a greater effect upon this question in this country than the World's Fair at Chicago in 1893. The inspiration of the wonderfully impressive massing and grouping of the beautiful and harmonious buildings of the Court of Honor is beginning to bear fruit in various ways. Hundreds of thousands of people saw and felt the value of this and carried the lesson to their home cities. Previous to this there had been in this country no concrete example to which we could refer, but now, thanks to this inspiration, we are beginning to find springing up all over this broad land of ours, wherever cities are prosperous and progressive, a desire, and in many cities a distinct movement, to accomplish something really inspiring and fine in the way of a group of public buildings.

1. *Washington.* — In perhaps no city has the Chicago World's Fair inspiration had a more marked effect than in the recent proposed improvements in Washington. Here, however, it must be borne in mind that the distinguished commission proposing these improvements was privileged to start with a really good city plan. It is a significant tribute to the genius of Major L'Enfant and to the good judgment of the commission (perhaps the most eminent group of specialists in this line in America, if not in the world), that, so far as the central portion of the city is concerned, the result of their thorough study, and a most careful inspection of the best European and other examples, has led them to unqualifiedly recommend the return to the original scheme as laid down by L'Enfant. The central feature of this scheme was "The Mall" (Fig. 2), and the commissioners have rescued this tract from the miserable state into which years of neglect had allowed it to sink, and legislative enactment has at last been obtained which will forever maintain this area for the purposes for which it was originally intended. Here will be laid out from the Capitol to the Potomac one of the grandest avenues, or set of avenues, in the world, flanking broad level lawns, shaded by noble trees and furnishing grand sites for the nation's public buildings.

2. *Cleveland.* — One of the first American cities to take up this important matter was Cleveland, Ohio. Here, soon after the Chicago World's Fair had closed, and while its influence was strongly felt, agitation was commenced upon the question of grouping in an impressive manner a number of public buildings of which the city stood in need. After some little preliminary discussion, the city government very wisely decided to place

this most important problem in the hands of an expert commission, with Mr. Daniel A. Burnham, of Chicago (the master mind in creating the Court of Honor there), at its head. This commission, after careful study of the whole problem, has issued its report, and its principal recommendations have not only been adopted, but much of the land has been condemned and progress made upon construction. When this work shall have been completed, "The Forest City of the West" will be able to offer to the world an example of impressively massed public buildings hardly possible to be excelled, certainly not at the present time. The experts here employed have recognized and incorporated in their scheme the two important existing elements of the lower portion of the city, the Central Station (the gateway of the present-day city) and the "City Square" (the terminus of the far-famed Euclid Avenue leading thence out to the magnificent residential and park districts of the city). A new station was a necessity, and it is now to be so placed as to form not only a magnificent gateway to the city, but the fitting terminus to the broad, tree-shaded and beautifully-proportioned mall leading to the City Square.

Along the mall, and so placed as to become harmonious parts of a most artistic composition, are to be grouped the desired buildings. Nearest the station, and separated from it by a wide tree-shaded esplanade, are the court house and city hall, and between them a grand fountain court. "The Mall," with its tree-shaded avenues, its grassed lawns and slopes, and its fountain basin, leads thence to the "City Square," and here are grouped the public library, the post-office, the Chamber of Commerce and other buildings, all to be of uniform and harmonious architectural design.

3. *St. Louis.* — Here a very interesting plan has been prepared by the Public Buildings Commission of the city for the grouping of a number of much-needed public buildings, two of which, namely, the public library and city hall, had already been started, with no thought of their relation to one another (Fig. 3). In the scheme proposed all the space between two north and south streets of the city is condemned and utilized as a mall, at the north end of which is the new public library, while at the southerly end is a civic plaza with the new city hall at one side, flanked by a much-needed new court house, and the whole scheme rounded out and completed by a building for a fire department headquarters, an administration building and a greatly-desired building for a police headquarters and jail. Each

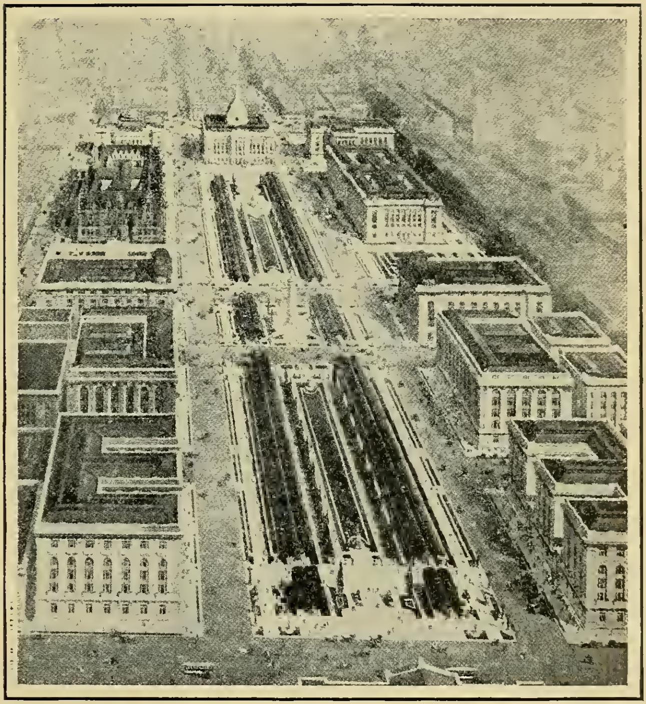


FIG. 3. PROPOSED CIVIC CENTER AT ST. LOUIS, MO.

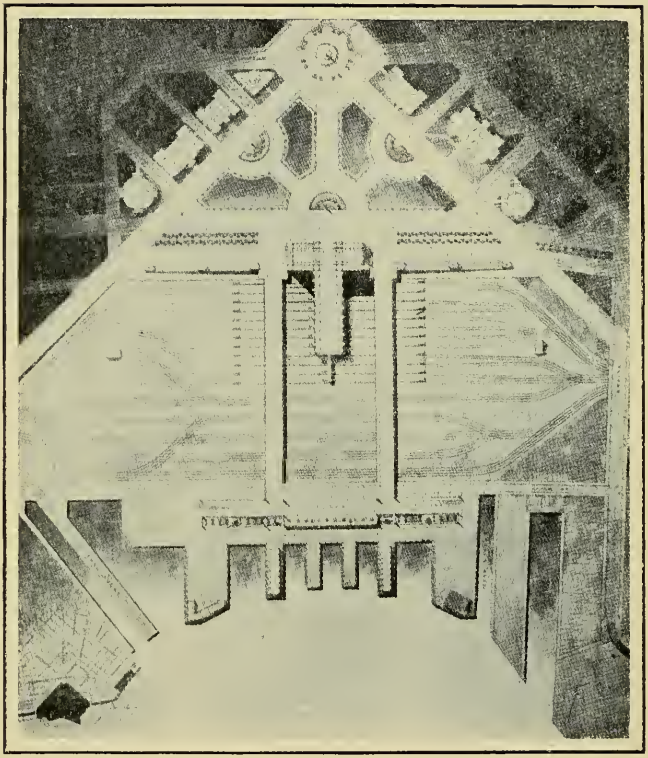


Fig. 4. Proposed Civic Center at Buffalo, N. Y.

of these will add to the beauty and impressiveness of the group, and when all are completed will furnish convenient and accessible housing for the city's business in a way that will add immensely to St. Louis's civic importance.

Along the mall and facing it would be most desirable sites for quasi-public buildings, such as theaters, hotels and the like. As the commissioners well say, "St. Louis has the opportunity, at a little more than the cost of the buildings, which are an immediate necessity, of securing a breathing space, a beauty spot and a scheme for present grouping and future development of which its citizens may all be proud." Since this plan was prepared another similar but less elaborate grouping has been submitted, either of which would greatly benefit the city's appearance.

Not only this, but far-reaching plans for river front improvements have also been studied and are in a fair way of adoption. Should Boston neglect its opportunities of like character?

4. *St. Paul.* — Here the new state capitol, which had been given a commanding site and appeared well from distant points, was almost lost in a maze of nearby streets and the crowding of houses about it, conditions not unlike those of our own State House. A triple radiation of avenues is now proposed that, when executed, will greatly add to the impressive appearance of this beautiful building from all of its principal approaches, besides bringing into the scheme, by means of one of these avenues, a fine new cathedral, and furnishing as well a splendid municipal court leading in the direction of the business district, upon which future city buildings will face. The third avenue, extending southward at right angles to the principal façade of the building, will furnish a most impressive approach from this direction. This avenue shows an interesting method of treating a steep grade which exists here, by means of skillfully arranged drives within a rectangular parked area, in the center of which a soldiers' monument is some day to be placed.

5. *Buffalo.* — Here we have a scheme for the grouping of public buildings about a plaza and parked extension of Niagara Square at the foot of Delaware Avenue, extending to the lake shore near "The Terrace" (Fig. 4). This will provide fine sites for a number of needed public buildings, will insure a much more beautiful setting for the present city hall, which is brought into the scheme, and will also furnish a site for a proposed new union station on the lake shore. In this connection an interest-

ing feature is the provision for a loop track, so that trains coming into Buffalo may pass around this loop and thence out of the city, thus avoiding the inconvenient and confusing switch-back arrangement now in use. One gentleman is largely responsible for this movement, and has, I believe, even gone to the expense of securing options on much of this land, and the scheme is likely to go through. The railroad contemplates spending some $15 000 000 and the city between $5 000 000 and $10 000 000 more.

6. At *Philadelphia* a wide new avenue is proposed and the land condemned, extending in a straight line from the city hall to the principal entrance to Fairmount Park. This will cost perhaps $5 000 000, but will well repay this expenditure in the increased beauty, dignity and convenience which it will afford. It will greatly add to the impressiveness of the magnificent city hall and will make the park system much more accessible.

7. *New York.* — The Municipal Art Society of the City of New York, through its Committee on Civic Centers, has issued a report containing an interesting plan for the development of a magnificently impressive civic center at City Hall Square. The existing very beautiful city hall building is preserved and given a much more fitting setting by the removal of all the other more or less inferior buildings that now encumber the square, including the very ugly post-office building. All the existing buildings on the northerly side of Chambers Street are removed and replaced by those of a more monumental character, to be utilized for the housing of the various departments of the city's business. The plan calls for a more adequate arrangement for the handling of the immense throngs that utilize the Brooklyn Bridge terminal here, and in this connection a colossal towering structure will balance the existing skyscrapers of Park Row and Broadway nearby and furnish apparently ample office accommodation for New York's city officials for years to come. At Brooklyn a grand plaza has been proposed, so located as to be the point of meeting of avenues leading thence to the East River and Manhattan bridges, and serving thus to amply connect the heart of this great borough with Manhattan Island, diverting and controlling the immense traffic to and fro, and offering as well grand sites for the various office buildings of the borough of Kings County. Time and space allow for but the briefest glance and mention of the other improvements of a similar nature proposed for the civic betterment of this great metropolis. These include the Battery Park improvement, a subway loop terminal for

the new Blackwell's Island bridge, the proposed Chelsea improvements with an elevated roadway on West Street, a widening of 181st Street and many other changes in Manhattan and the Bronx.

These are but a few of the more important cities that are undertaking, or at least planning, improvements of this sort. Others that might be mentioned are San Francisco, Oakland and Los Angeles, Cal.; Denver, Colo.; Columbia and Greenville, S. C.; Montreal, Canada; and even far-away Honolulu, Manila and Rio Janiero.

Boston. — With these examples before us of what has been and is now being accomplished, let us see what our own city has to offer in the way of possibilities. We shall find a number of such opportunities awaiting development. We have seen that, as in Paris, Vienna and Berlin, every large city has or may have several civic centers, and that in the best and most comprehensive design these all bear a certain relation to one another and are bound together by well-arranged avenues or boulevards into an effective city plan, so here in Boston we have several opportunities for effectively grouping our needed new buildings into impressive civic centers. At Copley Square will undoubtedly be one; at Park Square perhaps another. Much of our artistic and musical life is moving out toward the Fens, and there is growing here what will eventually be another important grouping of beautiful buildings. Suggestions for an improvement of conditions here have recently been made in the report of the Committee on Municipal Improvements of the Boston Society of Architects. This valuable report also brings out such interesting suggestions as an island in the Charles River Basin; a fitting plaza treatment for the terminus of Commonwealth Avenue at the Public Garden; this latter in connection with proposed widening of Arlington Street and its extension south of Boylston Street to Shawmut Avenue, with a city hall site at Tremont Street opposite the Castle Square Theater.

The most striking feature of our city, however, is Beacon Hill, which, with its noble, gilded-dome State House, dominates the community and is the cynosure of all eyes. It is my belief that this central feature of our city has as yet been too little appreciated, and that a plan may be developed which shall fittingly recognize this hill, and as a result provide for our State House a more dignified setting, with opportunities for its enlargement; also sites for many much-needed buildings, and a desirable connecting link in our parkway system at the same time.

Some twelve or fourteen years ago Charles Eliot, one of the elder Olmsted's gifted disciples, proposed an improvement to Boston's water-front and the mouth of the Charles River which involved, among other desirable things, the removal of the North Station to the Charlestown side of the river. My attention was attracted to this plan a few years ago, and to the fact that such a change would offer opportunities for grouping public buildings here on the water-front in an impressive and dignified manner. Let me quote from a letter written by Mr. Eliot at that time to the Joint Board for the Improvement of the Charles River. This letter was not published until about five years ago, when it appeared in the account of his life, edited by his father, President Eliot of Harvard University:

"At the northern end of the basin (see Eliot plan, Fig. 5), that part of the river which lies between East Cambridge, Charlestown and Boston is choked by innumerable piles supporting railroad bridges. The cost of space for a suitable Union Station on the mainland of Boston being very great, the railroads have contrived to obtain permission to cover the river with a timber platform which they use as a rent-free switching yard and terminal. It is well known that, in view of national and state legislation, this virtual obliteration of the river by the railroads is only temporarily permitted. When the renewal of this permission shall be at last refused, the railroads will be compelled to place their terminal station on the north bank of the Charles River, presumably about in the position indicated upon the plan. By this arrangement the breadth of the stream will be restored and the banks and bridges will become susceptible of fine architectural treatment.

"As compared with the present stand, this new station will be distant from the corner of Washington and Summer streets about half as far again; from Copley Square it will not be farther distant than the present station, and the route to it by way of Dartmouth Street and the banks of the Charles will be much more agreeable than the route through the city which is followed to-day. In this connection the plan suggests an improved position for the future bridge to Charlestown and a way of entrance into the city for a boulevard leading from the northern suburbs by way of Sullivan Square, Charlestown, to both Lafayette Square, Cambridge, and the Back Bay."

You will note that the plan herewith submitted (Fig. 6) modifies this suggestion somewhat, for it seemed to me desirable, upon more careful study of all conditions, to go a step further, and, by means of a wide avenue with tree-shaded malls, connect our State House and Common with this water-front improvement. The scheme here presented, then, comprehends, as you

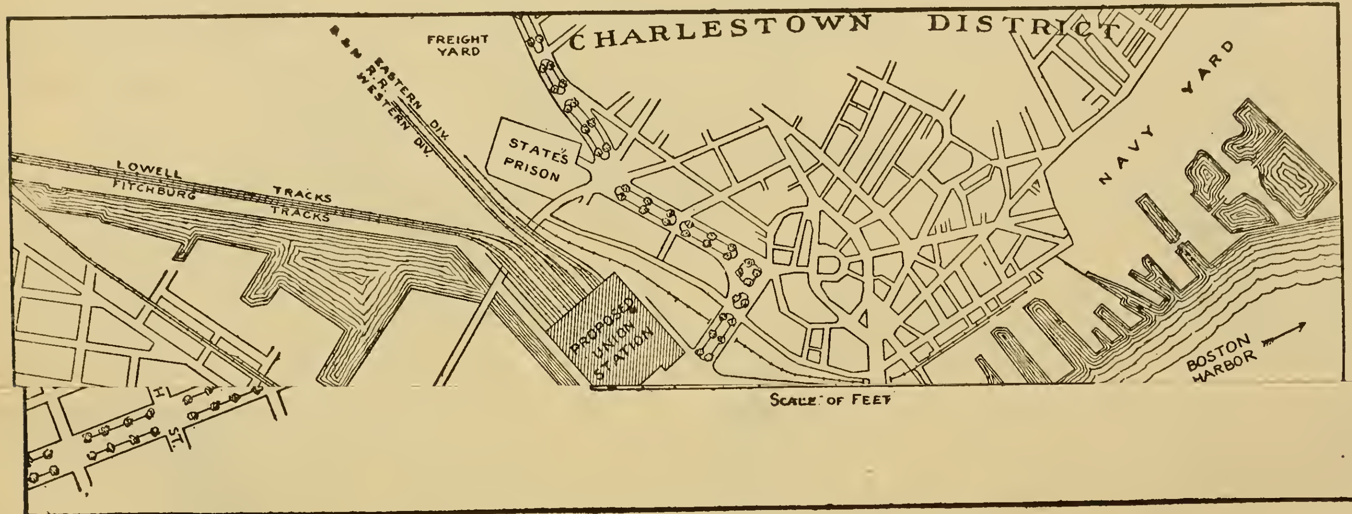
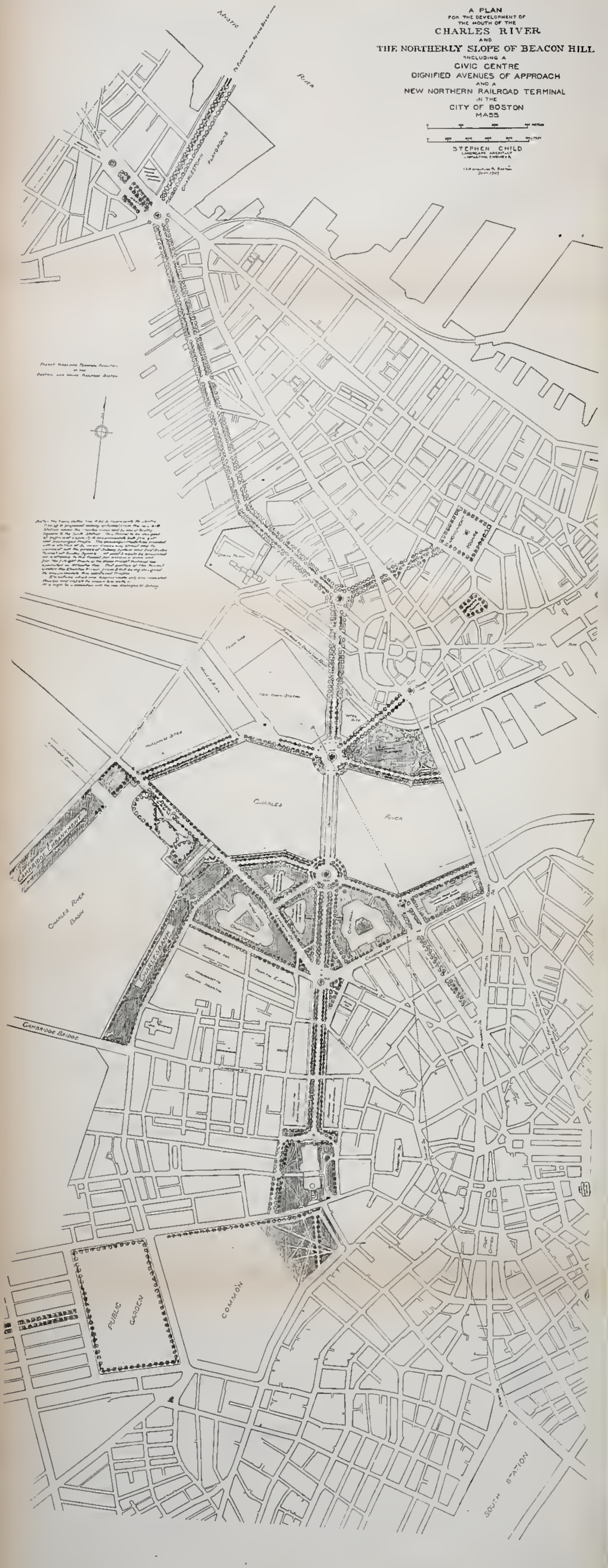


FIG. 5. (REPRODUCED BY KIND PERMISSION OF PRESIDENT ELIOT.)

FIG. 5. (REPRODUCED BY KIND PERMISSION OF PRESIDENT ELIOT.)

FIG. 6.


A PLAN
FOR THE DEVELOPMENT OF
THE MOUTH OF THE
CHARLES RIVER
AND
THE NORTHERLY SLOPE OF BEACON HILL
INCLUDING A
CIVIC CENTRE
DIGNIFIED AVENUES OF APPROACH
AND A
NEW NORTHERN RAILROAD TERMINAL
IN THE
CITY OF BOSTON
MASS
STEPHEN CHILD
LANDSCAPE ARCHITECT
CONSULTING ENGINEER
MYSTIC
RIVER
CHARLESTOWN
PLAYGROUND
NEW NORTH STATION
CHARLES
RIVER
CHARLES RIVER
BASIN
CAMBRIDGE EMBANKMENT
CHARLESBANK
CAMBRIDGE BRIDGE
CITY HALL
POST OFFICE
PUBLIC
GARDEN
COMMON
SOUTH STATION

will see, in a general way, the development of the north slope of Beacon Hill and of what might be termed the "Lower Charles River Basin," and, therefore, supplements and completes the magnificent development now going forward above the new dam at Craigie Bridge. It recognizes Beacon Hill and the State House as the crowning feature of our city, and provides not only a more dignified and adequate setting for this noble structure, but opportunity for its enlargement, as well as sites for a number of other much needed buildings to be built from time to time, and for a new North Station. Furthermore, it secures to our citizens what has long been wanting, namely, a means of reaching, in an agreeable manner, the Middlesex Fells and the Revere Beach reservations of our Metropolitan park system. The scheme provides a monumental tree-shaded avenue, which starts from Boston Common and the State House and proceeds northerly down the slope of Beacon Hill in a direction parallel with existing lines of streets, and so arranged that the dome of the State House and the beautiful north façade of that building are both recognized and can be thoroughly appreciated by those approaching from the north. What is actually proposed is the wiping out of all of the existing structures between the easterly street line of Temple Street and the westerly street line of Hancock Street from Derne Street, at the rear of the State House, down to Cambridge Street. A strip of land approximately 200 ft. wide is thus secured, which could be subdivided as shown, for an avenue or parkway, and its extension in a direct line northerly will almost exactly coincide with the existing easterly line of Staniford Street and the westerly line of Lynde Street. It is to be noted that within this area there are almost no buildings of very great value. I have suggested a subdivision of this 200-ft. strip as follows: In the center a 50-ft. avenue for pleasure driving only, flanked on either side by wide malls, tree-shaded, and affording ample opportunity for agreeable promenades and for viewing the pleasure driving of the central avenue. On either side of these tree-shaded malls are 25-ft. roadways for the service of the adjacent property and for teaming and all such traffic, and in addition space for an ample sidewalk, 12.5 ft. wide, adjoining the property lines. On the right and left of this avenue would be sites for future properly restricted buildings. State House growth might well be provided for here. The avenue would broaden out into a wide circular plaza at the river's mouth upon which may front, in a dignified and adequate manner, appropriate to a maritime city of Boston's importance, public

buildings, of which I shall speak in more detail later. This avenue would continue in a direct line by a monumental bridge over the lower Charles River Basin to another broad plaza similar to that at the southern end of the bridge, and upon this plaza would face the proposed new North Station. In some such way we could secure a fitting and dignified entrance to our city for the thousands of travelers and commuters entering from the north, and give them an opportunity of seeing and appreciating our noble State House as well as other public buildings.

Continuing with the general features of the plan, we see that the avenue, somewhat narrowed now, passes by a raised viaduct over the tracks of the branch railroad to the Hoosac Tunnel docks and the Navy Yard and over other important freight facilities (which would by this means be entirely undisturbed) to a circle and vista point from which avenues separate; that to the east providing (what is now much desired) an agreeable means of driving to Bunker Hill Monument, and that to the north, by a widening and parking of Rutherford Avenue, furnishing a parkway leading through Sullivan Square, redesigned and improved, and thence proceeding either by Broadway or Mystic Avenue (widened and parked) to Broadway Park, Somerville, whence there is now a beautiful parkway approach to the Middlesex Fells. From Sullivan Square an avenue should be studied leading to the east, past the Charlestown playground and crossing the Everett Bridge by way of Broadway, widened and parked, meeting the new Revere Beach parkway at Everett, thus furnishing an agreeable means of reaching this popular reservation from the heart of the city — a desirable improvement.

So much for the general features of the plan. A brief consideration of some of the more important details may be of interest. The first and perhaps most important to great numbers of our citizens is the proposition to move the North Station across the river. I can almost hear some of our practical friends saying, "Why move our station farther away? We want greater convenience, not less." Very true, and if utility and convenience were the sole considerations, perhaps it would be well to tunnel under our city from both north and south, and, coming up at the Common, build there a great union station for all the roads entering Boston. I am afraid, however, in spite of the convenience derived, public sentiment would hardly sanction such a desecration of our sacred Common. I trust not, for I believe there is a better solution. We have seen that as far back as 1894 thoughtful people were proposing the relocation of

this station at about the point here shown, and there is no doubt that the arguments then advanced still hold good and can be reinforced by others. No one doubts that the railroads are simply permitted to encumber the river here with "innumerable piles and bridges" and to utilize these timber platform, switch yards and terminal facilities "rent free." Neither is it to be doubted that such permission has been of incalculable value, not alone to the railroads, but to the great community which they serve. That at some day not long distant national and state governments will undoubtedly withdraw these permits can hardly be doubted, especially if it can be shown that great improvements to our city can thus be accomplished. But convenient and liberal provisions for terminal facilities are of such vital importance to the well-being of the entire community that projects for changing them should not be entered upon lightly or without offering distinct improvements over those now existing.

When such improvements can be demonstrated, however, it has been the universal experience that there are no more progressive and liberal-minded people in the world than the presidents and directors of our great railroad systems, and the enormous sums of money that they are to-day expending to secure not simply adequate, but monumentally attractive terminal railroad stations in the great cities of this country alone (not to mention Europe), are almost incredible. We have already alluded to some of these. At Washington, for example, a $3 000 000 white marble station is in process of erection, to be reached by tunnels, and one of the most gratifying things in the situation there was the fine spirit with which the late President Cassatt and the Pennsylvania Railroad directors met the suggestions of the improvement commission. For it must be remembered that the Pennsylvania Railroad owned and occupied fifteen or twenty acres of land upon which were located a station and terminal yards directly in the way of the proposed mall improvement.

We have seen what the Lake Shore Railroad has been willing to do at Cleveland, what the New York Central is to do at Buffalo. We hear of new $30 000 000 terminal facilities to be provided for Chicago, and we know of the $10 000 000 Pennsylvania Railroad station in process of construction in New York, and now comes the New York Central, after only a few years' use of a completely remodeled station at Forty-second Street, and proposes to tear that one down, replacing it by a more

commodious and certainly much more beautiful structure, a great ornament to the city and added proof of the progressive and liberal spirit of that great corporation. In addition to this, and as a part of the scheme for the new Grand Central Station, a temporary one at an expense of $200 000 will have to be erected and later torn down. Undoubtedly none of these great undertakings are entered upon without a careful consideration of the cost and of the probable return to the corporation interested. Let us see whether there may not be some such factors that will be of interest to the Boston & Maine system and its thousands of patrons by our proposed move. Practically considered, the present station is already overcrowded, leaky and poorly ventilated. The delays due to the congestion of traffic at the drawbridges are expensive and annoying. The station is, to say the least, not an ornament to our city, nor a fitting terminal for one of the great railroad systems of America. The move proposed is in a direction that will involve as slight an expenditure of money as any that could be suggested, perhaps, for it would place the station where it would conveniently receive all the various divisions of the system without necessitating a narrowing up of the trackage facilities for the purpose of crossing any bridge or similar obstacle. It is in fact here located (see plan) just south of the point where all the tracks now meet; but, we are told, it removes the patron just so much farther from the heart of the city. Charles Eliot has already told us how comparatively little this would amount to, but let us see if modern engineering achievements may not obviate even this difficulty. What good reason would there be, for example, why the various railroad systems entering Boston should not be allowed, under proper restriction, to tunnel the city from this new North Station to the South Station, and build a subway (see line on plan) to accommodate (as will the Pennsylvania Railroad tunnels in New York) not only passenger but freight traffic, thus relieving the crowded and circuitous "Grand Junction" freight line from Cottage Farm to Charlestown, and thereby also helping to solve the knotty problem of the Brookline Street bridge at Cottage Farm.

A tunnel as here suggested could be arranged so that its passenger tracks could have one or more connections with our subway system in the city. It would then be possible for a passenger arriving from the north to do either one of several things. He could stretch his travel-cramped limbs by a delightful walk across an imposing plaza and bridge, getting a fine

first impression of our city, with views of monumental city buildings and of the shipping in the foreground, unmarred by any hideous elevated structures. He could, if so disposed, continue his walk (perhaps lured by the gilded dome of the State House) up a wide tree-shaded mall to the Common; he could follow the river bank on either side by tree-shaded promenades to the beautiful Charles River Basin, the Charlesbank and Riverbank parks. If he were not so actively disposed he could enjoy all this from a carriage and drive on out into the park system in either direction.

If, on the contrary, he is a hurrying commuter or a rushing traveling man, he can go down a flight of steps, or better yet an elevator, and take a car that will whisk him under the city, leave him if needs be at Scollay Square, Park Street or Summer Street, or rush him through to the South Station in say five minutes' time, amply sufficient to catch his New York or Chicago express, or transfer to a suburban service train for Brookline or Newton. Furthermore, this plan would offer to the railroad company certain definite opportunities for reimbursing themselves to a considerable extent for the outlay. The land now utilized for station and yards would have a value to the city or county for its buildings. The improvement to the water-front, the bridges, parkways, and so on would enhance this value. Not only that, but the region to the west of the proposed new station, now a freight yard, might become the site of warehouses that would rival those at South Boston (Woolville so-called) in business facilities. Here, with fine railroad accommodations, and with Miller's River widened and deepened offering shipping facilities, and with upper and lower roadways, the lower connecting the shipping passages with the basement floor of these buildings, this territory would be of great commercial value and a source of revenue to its owners. The great foresight of this railroad system in already securing the old McLean Asylum grounds gives them the needed chance to expand and accommodate their constantly increasing freight-traffic needs in this direction. It is a noticeable fact also that the present railroad buildings on the north side of the river here are all of them old and most of them of a distinctly temporary character and of little intrinsic value, and it will, therefore, not be a great sacrifice to do away with them, replacing them a little farther out, say on the old asylum grounds, by up-to-date structures more efficiently planned for modern needs. There is nothing in these arguments that would in the least interfere with the proposed

merger of the Boston & Maine system with the New York, New Haven & Hartford, and indeed much that might be advantageous to such a proposition.

Assuming, then, that these advantages are sufficient to warrant this move on the part of the railroad company, what can be said in favor of utilizing the territory thus made available for a grand civic center? Boston, the chief port of New England, famous for its maritime history, should look to the development of its water-front, and what more appropriate location could be suggested than this for its chief city buildings. The crying need for a new and commodious City Hall has been admitted for years. Commissioners are now investigating the crowded condition of the State House and of Suffolk County Court House; our various metropolitan commissioners are now housed in scattered office buildings for which the community pays large sums in rentals. A new custom house and appraisers stores is proposed; why not, then, proceed in a thorough manner to wipe out the crowded slum district hereabout, providing carefully for model tenements elsewhere, and set aside this water-front region for the buildings so much needed? Here they can be conveniently grouped in a dignified manner, perhaps in some such general way as is here suggested, and, with the proper architectural treatment of buildings, grounds, plazas, avenues, bridges and abutment walls, give to our beloved old city a magnificent approach and an administrative center of which we could really be proud.

There is much talk of the need of economy in public expenditures, and no doubt it is greatly to be desired, but I believe the expenditure involved in the execution of some such plan as this would be true economy and would bring returns of incalculable value to the city and state. The need of a comprehensive study of all such matters by a broad-minded Civic Improvement Commission has been met by the appointment by Governor Guild of the Commission on Metropolitan Improvements, who will undoubtedly study the whole question broadly and set about the execution not in any wholesale, extravagant manner, but after deliberate study of all desirable plans.

I believe the idea so successfully adopted in many European and some American cities, of acquiring and holding all the lands adjacent to, as well as specifically occupied by, the desired improvements, so that the entire community may benefit by the increased value due to these improvements, is a good one and will result in saving immense sums of money to the community.

We have seen what our neighbors at New York, Philadelphia, Washington, Cleveland and other cities are doing in these respects. Let us not be behindhand. To stand still is to go backward. Our cousin Dietrich Knickerbocker of New York, and our hustling western brothers, are fond of poking fun at the provincialism of our city and our weakness for assuming that Boston is the "Athens of America," and that here is located the real "Hub of the Universe." Now all really good Bostonians know that our claims in these respects are genuine, and we would never admit otherwise to the world, but "just between friends, now," isn't it a fact that while the Hub may be solid and strong, and the rim sound and true, some of the spokes are sadly bent and broken and in need of paint or some other suitable decoration? Let us look to them before it becomes too late; let us straighten and repair them, and, above all, let us see to it that our acropolis on Beacon Hill is treated in a manner worthy of our city, "the Athens of America," which it so nobly crowns.

DISCUSSION.

The President. — I am very glad one of our members has taken up this subject in which we are all interested. The engineers have not considered this question as much as our brothers of the architectural profession, and in all discussions of plans for civic improvement I have noticed that one particular gentleman of that profession has been especially prominent. He has devoted a great deal of time to this matter, and he has kindly accepted my invitation to be here tonight — Mr. C. Howard Walker.

Mr. Walker. — I was not fortunate enough to be here during the early part of Mr. Child's paper, so I did not hear all that he said in regard to foreign cities.

I am not a pessimist in regard to Boston, but I seriously believe and make the statement that there is no city in America that has lost so many admirable opportunities excepting in the single instance of our park system, as has the city of Boston. We have the best opportunities that any city could possibly have. We have the opportunity of the river, of the harbor, of hills that are not too high. From the Common we have treated the park problem on the line of Commonwealth Avenue and the parks beyond, and treated it admirably. Everywhere else we have treated problems as matters of the moment only, not for the future.

Seventeen years ago I worked on a plan for an avenue from

the back of the State House down to the river. Accumulated experience is a very useful thing, and four different times I have seen similar plans suggested. Undoubtedly it must be done at some future time. It is the natural approach from the north of the city.

When I first went into an architect's office twenty-eight years ago there was a little man from Watertown who was making a drawing of the Charles River Basin, which was brought into Mr. Sturgis' office, and I had the good fortune to work upon it, and for fifteen years nothing very much was done in regard to the treatment of this basin. Now the Charles River is being developed, and being developed at a cost so much greater than would have been then incurred that it was certainly not farsighted that the proposition was not taken up at that time.

Now the question has come up about an island in the Charles, and to my surprise and amazement I have had within the last week several residents of the water side of Beacon Street come to me and say they believed that the island would be a good thing. Here is a proposition to make, in the Charles River, land that will divide the river and make that enormous area smaller, and leave on each side of that island a river the size of the Seine in Paris and on one side a river wider than the Thames in London, and still leave an area for a basin at the end of Dartmouth Street four times the size of Alster Basin at Hamburg. The effect of an opportunity to get land upon which to build without paying for it (practically, at least, without its costing the enormous sum that it would cost to buy land), it seems to me would be very great.

In regard to the question of a tunnel between the North and South stations, the Committee of Seventeen of the Boston Society of Architects had, I think, forty-seven schemes for the development of the city of Boston. And those published were only published because they were threshed out from the others and because they did not seem to be too Utopian. But in some of those schemes this tunnel from the North to the South Station was a thing considered necessary and likely to come. The congestion now between those two stations is enormous. An open subway was suggested for teams, and it was found that teamsters were opposed to it. They considered that freight must go through a tunnel in trains or else had to be up on the street. But the tunnel proposition has been brought up again and again. The transit across this city must be underground, and the sooner we recognize that fact the better.

I don't know how much you realize the possible beauty of this city because of the fact that the streets are not straight. Take Cleveland, for instance, where the streets are straight and the city laid out in perfect squares, and there is never a completed vista at the end of the street. We have enormous opportunities for vistas in Boston. I wonder how many of you in going down Beacon Street have been impressed by the fire escape on the corner of the Houghton & Dutton building at the intersection of the streets. I am not saying anything about the building. It is inoffensive enough, if you please, but the fire escape need not be there, and if we had in the least the sense as individuals of making our streets attractive that the Latin races have, that fire escape would be taken off that building within twenty-four hours. It need not be there. It could be placed elsewhere just as well.

We have admirable opportunities at the ends and axes of streets. We are the only city which has a building-law height, and it has saved us a good deal; but we have a very difficult problem to deal with in regard to the large and broad effects. The small holdings are narrow and high. They are bound to be individual. You will find every front different from every other front, and that is a serious problem in making a city beautiful. So I think it is useless to expect that we shall have, without an effort of years, the sort of thing they have in Europe. I do not think we can attain that object without a long struggle.

I have been spoken to again and again, and certainly all of us have been, day after day, in regard to possible improvements, and the suggestions go on record, and some one in the next thirty or fifty or one hundred years who proposes improvements will have the accumulated record of the testimony, and he is going to succeed. The idea of making our streets broad, making well-arranged boulevards, with adequate means of circulation, does not mean a broad street going into a number of smaller ones. It means a continuous avenue from one place to another, having beautiful vistas and buildings worthy of being upon vistas. I wonder how many of you, looking at the photographs, noticed this fact: There was not one that showed a public building which did not have long lines and façades and dignified roofs, all of which tend to increase the dignity of city streets.

I am very much interested and pleased to see how this feeling is growing all over the country. Not only architects, but civil engineers, mechanical engineers, village improvement societies, are all hungry to try to find out how to perfect the heterogeneous

mass of material which has been erected during the last fifty years. We are trying to learn, and our very vitality, individuality and independence are the things in a certain sense which are standing in our way. But now we are beginning to find out the how and the way to do it, and I think that good results will come.

There is one thing I suppose I ought not to say, but I think that of all the miserable curses that ever attacked a city an elevated road is the worst. No matter what it does for transportation, it is deliberately cutting across circulation. It isn't like a simple wall; it isn't considered as a simple wall, and yet every proposition that has come up within the last four or five years in regard to circulation across this city has come across the elevated road. The proposition of getting the custom house with a really fine entrance at the foot of State Street encountered the elevated road. The proposition to get boulevards across the city and have really fine roads could not be acceded to because it cut across the elevated road. I believe as an actual fact that the very men who have advocated the elevated road, if they could live one hundred years from now, would wonder why they ever did it. The congested city has proved to itself time and time again, particularly in Budapest, in Paris, in London, that the best solution of the problem is underground transportation. It is the quickest and it is the best, and if there are elevated roads, they are in the sparsely populated districts, and even there the roads go underground as fast as the districts increase in population.

We cannot compass all these projects. This is an enormous proposition which Mr. Child has presented, a proposition which means a tremendous amount of dealing with large properties that are all entangled, and the taking of which would involve numerous legal questions, and I have been a witness in a very small case in regard to a very small piece of property within the last week, and it has taken about one hundred and fifty times too much time in red tape; and when I begin to look at a proposition like this that has to be dealt with by our brothers of the legal fraternity, I know that generations of them will have been born and have died before we get through with it. Of course we have the right of eminent domain, but there are constitutional questions involved, and it is going to be an extremely difficult matter for a people, for individuals governed as we are, to undertake such large projects until we have had a campaign of education. The thing that pleases me more than anything else is to see the differ-

ent societies taking up this subject, and that they really mean it and are feeling it. Until the mass of the people feels that this is necessary, it is only going to be a lukewarm matter; but the mass of the people is feeling it more and more every day, and I believe that such societies as the Civil Engineers, the Mechanical Engineers, the Society of Architects, the Metropolitan Improvement League and numberless other organizations that are springing up everywhere and taking up this question, will create a sentiment. After all, there never was any real art, architecture, painting or sculpture that was not based on the unanimous sentiment of the people.

THE PRESIDENT. — I remember when I was connected with the Boston park system we always had problems we had to struggle to carry out, and I know there was one gentleman who was of great assistance to the commission in articles which he wrote for the press. That gentleman is now the secretary of the Metropolitan Improvements Commission. The gentleman I refer to is Mr. Sylvester Baxter, who is with us to-night. I should be glad to have him say something.

MR. BAXTER. — I have enjoyed more than I can say being with you to-night and listening to this paper, and I am very sorry Mr. Child is not here himself. It is a great pleasure to me to see that the engineers are taking an esthetic interest in the problems that confront us. We have an example of it in our commission in Mr. Desmond FitzGerald, one of your most esteemed members, who has always taken an esthetic interest in public questions. The public owes a great deal to him for what he has been able to accomplish as an engineer in those directions, especially for his work at the Chestnut Hill Reservoir, in embellishing the surroundings and planting trees about that important feature of our water supply, imparting to a great work of utility the character of a beautiful pleasure ground. It is very hopeful that these things are being taken up by the engineers, as well as by the architects, intelligently and farsightedly.

I have been much interested in this problem presented to-night, because it presents a combination of dreams that have come true and of dreams that possibly may not come true, but which still are well worth considering and that, partially at least, may come true in time. You have shown Mr. Eliot's plan here to-night. I happen to have followed that very closely, as I was secretary of the preliminary Metropolitan Park Commission at the time the idea occurred to the author. Later it was presented to the joint board on the improvement of the Charles

River. I remember, and I might disclose some of the history of it here to-night, why this was not made public at the time; why it was not included in the report of the commission. It was because it was thought that it would not do to offend so powerful a corporation as the Boston & Maine by even suggesting the possibility of anything of that kind. But it was included in the life of Charles Eliot written by his father. Some of the most essential parts of it seem destined to come true in the carrying out of plans now under consideration. As to the Charles River Basin improvement, this has come true, and is coming true since Mr. Eliot died, and in even a more beautiful form than perhaps he figured. And certain aspects of this project here seem quite possible; some of the more essential portions of it may possibly come true through the carrying out of the "merger," the combination, in some shape, between the Boston & Maine and the New York, New Haven & Hartford.

Under the "merger," of course, there will be no occasion for a North Station, except a station similar in character to the Back Bay Station. As I understand the plan that the engineers of the New Haven were studying, it is to substitute for the present North Station, somewhere on the north side of the city, perhaps on or about the same site, a station partly or wholly under ground, similar to the Back Bay, and to make the South Station the great central station for the entire city, thereby effecting an economy which will amply pay for all the vast expenditures involved by diminishing by at least 75 per cent. the train movements in and out of the union station as thus organized. So there will be really no terminal station in Boston in the proper sense of the word, because all the trains, as I understand the "merger" proposition — all the trains coming in either way — will pass out through the city and out into the suburbs, and thereby effect that great economy and enormous convenience which the Boston public does not yet begin to appreciate,— the immense economy and convenience which will come from carrying out that plan. It is something which would be worth millions and millions and millions to the city and to Greater Boston in the economy and ease of getting from suburb to suburb and from one part of the metropolis to another, as well as to the most distant parts of the country.

These questions are now all being carefully considered — just beginning to be studied by the Metropolitan Improvements Commission. The basis of these studies, of course, must be the practical considerations involved. Beauty is founded upon

utility, and at the foundation of Boston are industry, commerce, trade. Hence, starting from these things, these studies must proceed and must be developed upon those bases. Therefore, the commission is beginning with the question of docks and terminals — the industrial aspects, such as accommodation of local conditions to manufacturing enterprises in various parts of the metropolitan district, and other utilitarian questions of that sort. And from a clear understanding of those things the elements of transit must be evolved, followed by the plan which will be useful and also beautiful because it is useful. That is what is hoped for. It has been very interesting to be able to perceive the sentiment as developed at the hearings that have thus far been held. There have been three hearings so far, private hearings, at which were representatives of commercial interests, of the great steamship companies running from Boston, members of the Chamber of Commerce who are intimately acquainted with the character of the grain trade and the transportation interests. It is very hopeful to see that among all those the sentiment is unanimous that there is no occasion whatever for any pessimistic talk about the future of Boston. Boston has the greatest of opportunities, and if these are properly taken advantage of, things are bound to come right. What is chiefly needed is to take hold of these problems with confidence and with a sense of unity, of solidarity.

The representatives of the foreign steamship interests tell us that our docks are obsolete; that the present docks of Boston are absolutely inadequate to the needs of modern commerce. For instance, the resident manager of the great International Mercantile Marine Company says that it was proposed very recently to put on to the Boston service the great steamship, the *Celtic*, one of the biggest steamers on that line, but their agent here said it was absolutely impracticable owing to the character of the docks. They couldn't possibly handle the business. And so Boston must have new docks in order to accommodate her growing commerce. These are some of the questions for the next year. Their practical development will be of the greatest interest, and I feel confident that the commission will welcome the coöperation of the engineers as they will also that of the architects.

[Note.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 16, 1908, for publication in a subsequent number of the Journal.]

PURIFICATION OF BOSTON SEWAGE: EXPERIMENTAL RESULTS AND PRACTICAL POSSIBILITIES.

C.-E. A. Winslow and Earle B. Phelps, Members of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, November 15, 1907.]

The Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology was founded in 1902 by an anonymous donor for the purpose of making experiments upon improved methods of sewage disposal. A large part of the work of the staff has been devoted to the study of the more purely scientific problems — chemical, bacteriological and hydraulic — which underlie the practice of sewage analysis and sewage purification. We have carried on, however, along with these theoretical investigations, an experimental study of the immediate local problem of sewage disposal as it is certain some day to confront the city of Boston.

The sewage of the Metropolitan district of Boston at the present time is discharged into the waters of the harbor at three different points.

The main outfall of the sewer of the north district carries some 50 000 000 gallons daily and discharges continuously off Deer Island. The sewage from the high level district passes out to Peddock's Island, near the southeastern limit of the harbor, and this amounts to about 20 000 000 gallons. The main outfall of the South Metropolitan district is at Moon Island, and here the sewage is stored in masonry tanks and discharged only on the turn of the tide. The daily flow in this sewer is in the neighborhood of 100 000 000 gallons.

The Massachusetts State Board of Health investigated the condition of Boston harbor in 1905 and found no serious damage from this method of disposal. The town of Wellesley has, however, recently been refused admittance to the Metropolitan system from fear of overtaxing the purifying power of the harbor (Report of Committee on Sewerage Commission, Wellesley, 1907). It can scarcely be doubted that the progressive increase of population within the drainage district itself will ultimately bring the problem of sewage purification to the fore. The present agitation in regard to the pollution of New York harbor under some-

what similar conditions is an indication of what must some day be expected in Boston.

Under these circumstances it is important to form some general idea beforehand as to what a proper purification of Boston sewage will involve; and our investigations have now reached a point at which this can approximately be determined. It should be understood that neither state nor municipal authorities are responsible for our conclusions. The investigations here reported proceed wholly from the Sewage Experiment Station of the Institute of Technology, and they deal with a coming problem rather than a present one. It is hoped, however, that they may yield data of importance in determining the feasibility of a disposal project when the time for it shall come, and offer some guidance as to its probable final form. Furthermore, as this is the first investigation to be completed of disposal of the sewage of a large American seaboard city, it is hoped that the results will have some interest for other cities similarly situated.*

This study has now been carried on for four years. The first two years were spent in a preliminary examination of various processes of sewage treatment as applied to this particular sewage, carried out in a number of small cypress tanks. These preliminary studies showed that it was feasible to treat the sewage on sand beds or on contact beds. The first process required a large area of land. The second process, the contact bed, yielded an effluent of fair quality, only when the sewage was passed through two successive beds; and again a large area was necessary. It was found possible to treat the sewage by the double contact process at a net rate of about 700 000 gallons per acre per day.

In these preliminary experiments it appeared that the trickling beds, or the percolating beds, as they are more commonly called in England, would furnish by far the most satisfactory solution of the problem. We did not feel justified in attaching great importance, however, to the results of the first two years' work on trickling beds. Although the small experimental filters yielded data of comparative value, particularly in regard to contact treatment, the success of the sprinkling bed depends so largely on the manner of design, and is so much affected by weather conditions, that it seemed necessary to have experiments on a larger scale and out-of-doors, upon which to base any final conclusions.

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* The full details of the experiments will be published in the *Technology Quarterly* for December, 1907.

Two years ago, therefore, two trickling beds were built, which were then the largest of their kind in operation in this country. Sewage from the main sewer of the South Metropolitan district was pumped directly into a tank which served for dosing the rest of the plant. Nothing was removed from the sewage before treatment except such screenings as would separate in passage through a section of 20-in. pipe set at right angles to the suction main, so as to form a grit chamber with a screen of bars half an inch apart. All the fine material in the sewage went into our distribution tank. From that tank a small portion wasted over a weir maintaining a constant head, and from the other end of the distribution tank sewage passed directly to one of the trickling filters. From the side of the distribution tank sewage passed through another pipe to the septic tanks, and from the last of five successive septic tanks the septic effluent passed out into the other one of the trickling beds. The septic tanks were, as has been said, five in number, built of cypress, 6 by 4 by 3 ft., and giving a storage period of twelve hours.

The trickling beds themselves were two in number. Each one was 8 ft. deep, and each had an area of 100 sq. ft. These beds were filled with 1½ to 2-inch crushed stone resting on 18 inches of large material. The sewage was at first distributed on the beds by a new method which has been developed at the station and which has some advantages — a method which we have called the gravity distribution method. The sewage flowed out through wooden troughs and dropped through the bottom of these troughs, through half-inch nozzles, on to concave metal disks and splashed up from the disks in fine spray.

During the first year of operation there were four of these splashing disks on each filter, and as the filters were operated at the rate of about 2 000 000 gallons per acre per day, or 5 000 gallons per day upon each of the two experimental filters, the flow through each nozzle was not very great and we did not obtain very satisfactory results in the way of distribution.

After a year's operation the distribution system was changed. On one filter — the one that took the crude sewage — a single splashing disk instead of four was substituted, the new disk taking four times the flow of each of the earlier ones. This worked very satisfactorily. On the other filter one of the Columbus pressure sprinkler nozzles was installed, but as this nozzle gave too high a discharge for our filter — a discharge in excess of 2 000 000 gallons per acre per day — we used an intermittent siphon tank to dose it. Half the sewage therefor flowed from the distribu-

tion tank directly on to one filter, being distributed by a gravity distribution system. The other half flowed through the septic tanks and from the last septic tank by an automatic siphon and the Columbus sprinkler on to the other bed. From the two filters the effluents were conducted through two separate pipes to sedimentation tanks, simple, conical tanks giving the effluent from the filter a two-hour storage.

Samples of sewage and of all effluents were taken every three hours, the samples being chloroformed as soon as they were taken and mixed and analyzed once a week so as to be thoroughly representative. In the study of these samples the ordinary chemical and bacteriological tests were made. Even greater importance, however, was attributed to tests of putrescibility. The object of sewage treatment is to obtain a stable effluent, and in dealing with the newer processes, the trickling bed and the contact bed, one finds that ordinary chemical methods of judging effluents are entirely inadequate. You may have one effluent entirely stable and of such a character as to be discharged into a stream without danger, and you may have another which is putrescible and which would cause a nuisance, and the analyses of these two effluents may be practically the same. Chemical methods are not sufficiently delicate to detect the difference between a good and a bad effluent. Fortunately there has recently been devised — it comes to us from Berlin — a simple method of measuring this elusive quality of putrescibility. This test is made by adding to a small sample of sewage a few drops of methylene blue solution and then bottling it up. The methylene blue is readily attacked by bacteria, but not so readily as oxygen or oxygen-containing compounds like nitrates and nitrites. When a sample of sewage is bottled up in this way the bacteria in the effluent first use up the dissolved oxygen, then the oxygen in nitrates and nitrites. When all this easily available oyxgen has been used up, the blue color rapidly disappears. The time during which the sample remains blue when bottled up in this way is a delicate measure of its stability, of the balance between oxygen and oxidizable matter. If the oxygen is in excess of the oxidizable matter, the methylene blue will retain its color. If the oxidizable matter is in excess, the oxygen will be used up and the methylene blue reduced and decolorized.

The first point to be considered in planning for a purification plant is the character of the sewage with which it will have to deal. We found that Boston sewage is an average domestic

sewage. It is weaker than the sewage of many small Massachusetts cities where there is a large proportion of house sewage. On the other hand, it is comparable with the sewage of the larger cities. Its organic content is slightly greater than that of the sewage of Columbus, Ohio, where Mr. Fuller and Mr. Johnson made their very careful study two years ago. For example, the oxygen-consumed value is 56 for Boston against 57 for Columbus, the free ammonia value is 13.9 against 11, and the Kjeldahl nitrogen figure is 9.1 against 9. Columbus sewage contains only 79 parts of volatile suspended solids, while Boston sewage has 91. On the other hand, Columbus sewage has 130 parts of fixed suspended solids against 44 parts for Boston.

The complete septic tank system consisted of five tanks. We tried, during the first year, the use of three tanks only, giving a storage period of seven hours. Later we added to the series the two other tanks, giving a storage capacity of 12 hours, but the change was not accompanied by any improvement in the results. Apparently the seven-hour period was as satisfactory as the longer one. The five small tanks were baffled so that their net effect was about that of a tank 30 ft. long, 4 ft. wide and 3 ft. deep.

Comparing analyses of the septic effluent with those of the crude sewage, it appears that the tank system removed 40 per cent. of the total suspended solids and 69 per cent. of the volatile suspended solids. There was a 29 per cent. decrease in total organic nitrogen and a 26 per cent. decrease in the organic nitrogen in solution, while the free ammonia increased by 20 per cent. The oxygen-consumed values were about the same in the effluent as in the crude sewage. The removal of organic matter from season to season did not vary materially as a whole, but soluble organic nitrogen was more reduced during the second and the third quarters of the year than at other times, whereas at the same seasons the production of ammonia was greater. These phenomena are both, of course, correlated with the increased bacterial growth in warm weather which has been noticed by Kinnicutt and Eddy at Worcester, and by Clark at Lawrence in connection with their studies of gas production in closed septic tanks. This point is of great importance in considering the efficiency of the septic tank under varying climatic conditions. Fowler has pointed out that in India septic tanks work perfectly, while in Russia they are unsatisfactory. In removing suspended solids the septic tank was least efficient just at the time of its greatest biological activity, when the bacteria were growing most rapidly

and there was the greatest stirring up of the tank and the most sludge carried over.

We studied the accumulation of sludge in the tanks rather carefully at three periods of the investigation, stirring up all the tanks and analyzing samples of the mixed tank contents, getting in that way the total amount of organic and inorganic matter stored. We measured 4 inches of sludge at the end of 12 months of operation and nearly 12 inches at the end of 20 months, so that the sludging up was proceeding at an appreciable rate. We found, however, by the analyses, in comparison with the analyses of inflowing sewage and of the effluent, that the tanks had done excellent work as far as the liquefying of organic matter went. For example, of the volatile suspended solids in the sewage, 69 per cent. went off in the effluent and 31 per cent. stayed in the tank. Of that 31 per cent. only 6 per cent. was stored, while 25 per cent. of the original amount present, four fifths of that stored, had been decomposed. Almost exactly the same proportion held for the organic nitrogen. Of the 29 per cent. which was removed by the tank, only 4 per cent. remained, and 25 per cent. of the total, or four fifths of that which was deposited in the tank, was liquefied.

On the other hand, it was interesting to notice that there was a slight increase in the fixed suspended solids, about 3 per cent. of the total amount in the sewage, due perhaps, to the precipitation of sulphides formed from the sulphates in the sea water. Our sewage resembles that of some of the western cities where they have hard water, since it contains a considerable amount of sulphate coming from the sea water which enters the sewers.

On the whole, the septic tanks did good work both in the removal of suspended matter and in its decomposition. Nevertheless, after two years, an appreciable amount of sludging had taken place, due largely to the accumulation of fixed solids.

In the operation of the trickling filters, some slight trouble was experienced during the first year. In the summer of 1906 a little clogging occurred and we found it necessary to work over the stone on the surface of the beds, though none of it was removed. But after the new sprinklers were put in place, the Columbus nozzle on one side and the single gravity sprinkling disk on the other, the filters worked admirably.

With regard to suspended solids, the amount discharged by the filters was found to be very close to that which was applied. On the crude sewage side it was slightly in excess, 138 parts per million against 135 parts per million in the applied

sewage. On the septic side the increase was greater, 86 parts per million going in and 96 parts per million coming out. The seasonal curve of suspended solids is very interesting. During three fourths of the years the filters diminished the suspended solids, but in the spring the effluent showed a great increase, the amount rising to twice or thrice the value for the applied sewage. This happened in both years in the same way with perfect regularity. It is interesting as showing that the trickling bed is a biological organism which is delicately adjusted. It is able to assimilate and store a certain amount of suspended solids and beyond that amount it begins to discharge. We found that the curve followed not the rainfall but the temperature. As the temperature went up in the spring, and as the bacteria began to multiply in the trickling bed, the load of solid matter on the stones increased until it reached the maximum thickness that could be sustained and then broke off of its own weight; the whole mass that had been accumulated during the preceding nine months came off in three months of the spring. But it came off in a stable condition and without danger to the effluent. The practical importance of this result lies in the strong hope which it furnishes of the permanence of the trickling bed. If the trickling bed is able to free itself of suspended solids in this way without damage to the effluent, there is no reason to anticipate permanent clogging of such beds when properly operated.

With regard to chemical constituents, the trickling bed showed, as usual, a considerable purification. For example, the total organic nitrogen was reduced by 22 per cent. on the crude sewage side and by 23 per cent. on the septic side. The organic nitrogen in solution was reduced by 47 and 44 per cent., and the free ammonia by 25 and 28 per cent., respectively. The oxygen consumed in solution decreased by 42 and 43 per cent. These figures, of course, would not indicate satisfactory purification if they told the whole story; judging from chemical results alone, we should say the beds were not doing good work. We should say the same thing judging any trickling bed or any contact bed by chemical analyses alone.

Five to six parts per million of nitrates were found in each case, and the effluents contained an ample supply of dissolved oxygen. The real test of a trickling effluent, however, is its stability, and this was measured by the methylene blue method. During the first year, results were not always satisfactory. Sometimes the samples would remain colored for two weeks, which was the maximum period for which they were kept. Some-

times they would lose their color in from two to four days. Results varied at different times and in the two filters. But after the installation of the new distribution system the results were very good indeed. From December 15, 1906, to June 28, 1907, 156 samples of each effluent were examined by the methylene blue test. On the crude sewage side, 127 samples out of 156 were stable for 14 days, 19 more were stable for over 4 days and 10 only became decolorized in 4 days or less at 20 degrees. The effluent of Filter B showed 129 samples out of 156 stable for 14 days, 16 more stable for more than 4 days and 11 decolorized in 4 days or less. In other words, 93 per cent. of both effluents were of sufficiently good quality to retain free oxygen for over 4 days, — a severe test, — and the results therefor indicate an effluent of satisfactory quality. The two beds gave results, as will be seen by the methylene blue figures, of approximately the same character. The effluent from the bed receiving the crude sewage was as good as the effluent from the bed receiving the septic effluent. This was one of the most important practical results of the experiments. There appeared to be no advantage in the preliminary septic treatment as far as final stability is concerned. Of course, the effluent from the bed receiving the septic effluent had less suspended matter than that from the bed receiving the crude sewage, but the purification was equally good and the stability of the effluent was equally good with the crude sewage.

At the close of 20 months' experimentation, the beds were taken to pieces and examined carefully. There was found on the crude sewage side a slight deposit about one foot down under the four old sprinklers. The rest of the bed was clean and the septic side was clean. The stone was in condition to be put in place again without washing. It is interesting to notice, however, that on the septic side there was a deposit half an inch thick all over the bottom of the filter, largely made up of sulphides, produced in the septic tank but not deposited there.

The effluents, of course, were turbid, containing a great deal of suspended matter, and under certain conditions this might be objectionable. In the hope of effecting an improvement in that respect we used our sedimentation tanks and found that by two hours' sedimentation it was possible to remove one half of the suspended matter present, greatly improving the appearance of the effluents. The price which must be paid for this additional improvement in appearance, however, is a somewhat serious one. Sedimentation means the disposal of sludge from sedimentation

tanks, and it was found that this amounted to between two and three cubic yards per million gallons of sewage treated. Although the effluent that comes from the filters is stable, the sludge alone is not always so; stability means a relation between oxygen and oxidizable matter, and if you separate the oxidizable matter from the oxygen, conditions are altered. It is therefore safer to discharge the sludge along with the effluent when it is possible to do so.

It seems, then, that the trickling bed will furnish a satisfactory solution of the problem of organic purification. But the problem of sewage purification is twofold. First, there is the question of nuisance; and, second, the question of getting rid of disease germs. For bacterial removal the rapid processes of sewage treatment are entirely inadequate. Comparing the effluent of Filter B with the crude sewage, it is apparent that the septic tank and the trickling bed combined reduced the total number of bacteria from 1 200 000 to 180 000, a diminution of 85 per cent., not one which could be considered satisfactory. Results regarding the removal of bacillus coli showed during the summer time even poorer results, the removal being under 50 per cent. by the septic tank and the trickling bed combined.

These results are as good as can be expected, for filters of this type cannot be relied upon to secure bacterial purification. For these reasons the Baltimore experts suggested secondary filtration through sand in order to avoid possible danger to the shellfish industry of Chesapeake Bay. The Board of Advisory Engineers of Baltimore estimated the cost of works for the complete treatment of 75 000 000 gallons of sewage per day at $3 283 250, of which sum $1 040 750, or more than 31 per cent., was for supplementary treatment on sand filters. The annual cost of operation was estimated at $115 500, of which $55 000, or 48 per cent., was for supplementary treatment. So that the treatment of the effluent from trickling beds so as to remove bacteria by the sand process is a costly procedure.

Fortunately, we have now a cheaper and equally efficient method of attaining the same end in the process of chemical disinfection. The application of chemicals as a method of sewage purification, that is, as a method for the removal of organic matter, has been pretty well discredited in most instances. But this problem is an entirely different one. In the old days the attempt was made to remove organic matter by the use of chemicals. Now, having oxidized the organic matter by the trickling bed, we may use chemicals for removing bacteria.

After the organic purification is attained, bacterial purification may be effected by chemical methods.

The first work that attracted attention to this point was that of Rideal in England, who, in a series of experiments at Guilford, showed the possibility of the treatment of sewage and sewage effluents with chloride of lime so as to secure a very large percentage of bacterial removal. Notice was first called to the practicability of the method in this country by Phelps and Carpenter about a year ago. Since that time the process has attracted much attention. It was found by Phelps and Carpenter that neither the addition of large amounts of bleaching powder up to 100 parts of available chlorine per million nor the storage of the effluent for periods of time up to 20 hours would remove all the bacteria. On the other hand, a comparatively low concentration of chlorine applied for 2 hours gave a very large reduction, the residual organisms being almost entirely saprophytic spore formers. Sterilization is, therefore, not feasible, but disinfection is.

It is important to distinguish between complete sterilization and a reasonable percentage purification, such as is attained in water filtration. Neglect of this discrimination has led to the use of excessive quantities of lime in certain recent German experiments. The character of the sewage, too, will materially affect the results. Good efficiency has been reported in recent experiments on the disinfection of septic effluent at Bengal, India. On the other hand, Kellerman, Pratt and Kimberley. in Ohio, found considerable quantities of lime necessary for treatment of certain effluents there.

In August, 1906, routine disinfection of the effluent from Filter A, taking the crude sewage, was begun, chloride of lime being added from a small orifice box as it flowed into the sedimentation tank at a rate of about five parts of available chlorine per million. This application gave very good results. It showed 99.99 per cent. purification on total bacteria and bacillus coli, which results are all that can be expected from any practical method.

The general conclusions from this work may be summarized as follows:

1. *Trickling Beds.* — The main result of this investigation has been to show the feasibility of treating Boston sewage on trickling beds so as to secure organic stability. In the experiments conducted, the filters were operated at a rate of about two million gallons per acre per day, which would call for 50 acres of

stone beds for the treatment of the sewage now discharged at Moon Island. A comparison with the problem of constructing 133 acres of contact beds, or 1 000 acres of sand beds, which would be necessary for other processes, indicates clearly that for this city the trickling bed offers the most practical method of treatment.

We have found that, with good distribution, a trickling bed 8 feet deep will operate successfully at all seasons, under local weather conditions. It removes about half the soluble organic matter, yielding an effluent which is somewhat turbid, but stable and well oxygenated. The organic matter present has been so worked over and purified by the bacteria in the filter as to be non-putrescible. Judged by the methylene blue reduction-test, 90 per cent. of the samples of the effluent are of such stability as to undergo no putrefactive change when kept closed up from the air for 4 days. Under ordinary conditions of discharge into open water such an effluent would be entirely unobjectionable.

The proper distribution on trickling beds can be attained either by the use of fixed sprinkler heads of the Columbus type, so arranged as to discharge intermittently at frequent intervals, or by the use of the splashing gravity distributors designed at the experiment station for this purpose.

With good distribution the trickling beds show no appreciable tendency to clog. During the greater part of the year, solid matter accumulates on the surface of the stones throughout the bed, but when this storage reaches a certain point, usually in the early spring, the solids break away and come off in the effluent in a stable condition. In a period covering two years the total amount of solid matter coming off balanced that going on. The filtering material at the end of the experiments was in excellent condition and showed no storage of nitrogen.

Our results point strongly to the advantage of operating trickling beds under conditions as uniform as possible. Resting periods proved distinctly detrimental to the work of the beds, and constant operation is to be recommended rather than any process which involves alternate working and resting periods.

2. *Septic Tanks.* — It appears from our experiments that Boston sewage may be treated in the septic tank with excellent results and that a period of 7 hours is a sufficiently long one. Thus operated, an open tank will remove 40 per cent. of the total suspended solids and 60 per cent. of the fixed suspended solids; its effluent shows a decrease of about 25 per cent. in organic nitrogen in solution and a corresponding increase in free ammonia.

The septic action on the stored solids is an active one, four fifths of the organic solids deposited disappearing in solution or as gas. Fixed solids gradually accumulate so as to render it probable that tanks would require cleaning about once in two years.

On the whole, however, our experiments indicate that the septic tank need not be used at all in the treatment of Boston sewage. Since November, 1906, when the distribution system was put in order, crude sewage has been treated on one of our trickling beds with perfect success. On the whole, the effluent from this filter was less frequently putrescible than that from the bed which received septic effluent. Furthermore, the filter taking septic effluent showed a deposit on its floor, due to secondary reducing changes, which was absent from the crude sewage bed. Furthermore, the absence of the odors produced by spraying septic sewage is an advantage of considerable moment in favor of the process of treating fresh sewage. Combined with the saving of the cost of tanks (in the neighborhood of $250 000) these arguments seem to indicate the treatment of crude sewage directly on trickling filters as most desirable. Modern devices for insuring a thorough preliminary screening should, however, be installed.

3. *Sedimentation of Trickling Effluents.* — The suspended solids which appear in the trickling effluent, though inoffensive, are unsightly and in many locations might require removal. By a sedimentation of two hours we have found it possible to remove about half the suspended solids. This clarification was accompanied by an improvement in stability.

In the case of Boston the currents of the harbor would be amply competent to care for the solid matter discharged if that matter were of an inoffensive and non-putrescible nature. Experience with the system at present in use has indicated this quite clearly. For a comparatively slight improvement in stability it does not appear to us justifiable to go to the expense of installing secondary sedimentation tanks. The sludge accumulating in such tanks would amount to 2 or 3 cubic yards per million gallons of effluent, a serious problem in itself. We are, therefore, of the opinion that the effluent from the trickling beds may best be discharged directly into the harbor as it comes from the beds. A stable effluent under such conditions could cause no nuisance, and if a submerged discharge were provided, its presence would scarcely be detected.

4. *Disinfection of Trickling Effluent.* — The problem of bacterial purification still remains to be considered, since the

trickling bed produces organic stability without destroying pathogenic bacteria. In the case of Boston harbor, with its large contiguous population, its bathers and its shellfish industry, this aspect is an important one. The experiments carried out during the last two years have made it clear that the effluents from trickling beds may be so purified bacterially by disinfection with chlorid of lime as to be of much better quality than the present streams entering Boston harbor. This bacterial purification requires about five parts of available chlorin per million and the cost of treatment would be within moderate limits.

The process of disinfection with chlorin can be applied to crude sewage as well as to trickling effluent, although experiments carried out at the Station indicate that about double the amount of chlorin is needed on account of the reducing action of the organic matter in the sewage. Pending the construction of a trickling filter plant for the treatment of the organic matter in Boston sewage, it might well be purified bacterially by this process at the present Moon Island outfall.

5. *General Plan for the Treatment of the Sewage of the South Metropolitan District.* — The sewage outfall of the South Metropolitan District at Moon Island is the one which threatens most seriously to menace the purity of Boston harbor, and it is this sewage which will certainly first require some different method of treatment. We have, therefore, considered, in a general way, the practical problem of dealing with this sewage in the light of the results of our experiments.

The most convenient location for a trickling filter area would be at the Calf Pasture in Dorchester, near the present pumping station. This is objectionable, however, on account of its proximity to the thickly settled portion of Dorchester. Furthermore, the necessity for excavating about ten feet of mud and refilling in its place would greatly increase the cost of construction at this point. The same objections apply to certain waste areas on the Neponset marshes which suggested themselves as possibly available. The headland of Squantum would offer an ideal opportunity for building trickling beds, but the difficulties of obtaining land in another town militate against the use of this site.

The southern portion of Thompson's Island would furnish a location free from all the objections to which the other sites are open. On an embankment 1 500 ft. long the sewage could be carried from Squantum across to the island, the effluent flowing

back along the same embankment to the existing outfall sewer. The pumping station at Dorchester, and the tanks and outlet at Moon Island, could thus be used without substantial changes. We have made preliminary estimates of the cost of building 50 acres of trickling beds, 8 feet deep, and equipped with the gravity distribution system, and are of the opinion that the cost, including the embankment with its two sewers, an efficient grit chamber, a reasonable purchase price for the necessary land, grading, stone filling brought to the island by water, concrete construction and sprinklers, would be in the neighborhood of $1 800 000.*

If this capital sum were borrowed at 5 per cent. on a twenty-five year loan, the annual expense for interest and sinking fund would be $126 800 a year, paying off the entire cost in the twenty-five year period. As a matter of fact, we see no reason to suppose that at the end of this time the plant would not be good for another twenty-five years without substantial reconstruction. The cost of operation, including extra pumping and supervision of screens and filters, would amount to $70 000 a year, bringing the total cost to about $200 000 a year, or $5.50 per million gallons of sewage treated.

The effluent from the trickling beds, wherever situated, could be further bacterially purified by disinfection with chlorid of lime at a cost of approximately $1.50 per million gallons, or $55 000 annually.

Pending the construction of filters for the removal of putrescible organic matter from Boston sewage, if it should seem desirable to secure bacterial purification, this may be effected by direct treatment of the crude sewage with chlorid of lime, which could probably be done for $3.00 per million gallons, or $110 000 annually.

Experiments are now in progress at the Experiment Station to test the practicability of higher rates of filtration and shallower beds than those used in the experiments on which these calculations are based, as well as on the treatment of sewage and effluents by electrolytically produced chlorin. It is hoped that these experiments may lead to a material reduction in the estimated cost of the purification processes. It seems clear, however, that the combination of trickling filters and chemical disinfection will solve the Boston sewage problem satisfactorily; and in the light of present knowledge these two methods are the most efficient and economical available for the purpose.

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* The authors desire to express their thanks to Mr. W. S. Johnson for assistance and advice in the preparation of these preliminary estimates.

DISCUSSION.

Mr. X. H. Goodnough. — I have had no opportunity to see this paper or to learn definitely what its tenor was before the meeting, so that I am not prepared to discuss it very fully. I did get some information as to what its conclusions might be from a statement in the Boston *Herald* this morning, outlining the paper in a general way, and there are a few things which I would like to say with regard to questions discussed therein.

In the first place, as to the experiments themselves, they add materially, of course, to our information as to methods of sewage disposal. And anything that adds to that information is a great help at the present time. The portion of this paper that I wish to consider, however, is the practical side.

The sewage of the city of Boston has now been discharged at Moon Island for a period of nearly twenty-four years. The quantity constantly increased in the first few years, — that is, beginning in 1884, it constantly increased for a few years, first by the growth of the city; then by the addition of the sewage of the Charles River Valley, in 1892; and later by that of the Neponset River Valley, about 1897 or 1898.

In 1904, on the other hand, by the completion of the high level sewer, the diversion of sewage from Moon Island to the new outlet at Nut Island was begun, and during the past year 33 000 000 gallons have been discharged daily at the latter outlet. The quantity ordinarily discharged at Moon Island at the present time is not measured and we have no means of knowing how much it is, but it probably averages less than 100 000 000 gallons per day.

A very thorough examination of the waters of the harbor made two years ago showed that, except in the immediate neighborhood of the main sewer outlets, the upper portion of the harbor was more seriously polluted than any other, that is, the portion about Fort Independence or Fort Winthrop. But even in this region the harbor waters are not objectionable to sight or smell.

The chief difficulty resulting from the discharge of sewage into Boston harbor at the present time is the effect of the sewage upon shellfish which have formerly been collected in considerable numbers from the flats in various parts of the harbor and the adjacent tidal estuaries. This pollution is caused, chiefly, not by the discharge of sewage from the outlet at Moon Island or any of the other main sewer outlets in Boston harbor, but by the discharge of sewage from minor outlets along the shores of the harbor and its tributaries, in the neighborhood of areas from which the shellfish are taken.

The most seriously objectionable conditions resulting from the pollution of local waters by sewage now existing are found in the valley of the Charles River and Stony Brook above the proposed new dam between Boston and Cambridge. A careful examination of Stony Brook in 1906 showed that the quantity of sewage being discharged into that stream from the sewers of the city of Boston had increased greatly as compared with the amount found there in 1902, and in its report to the legislature in January of the present year the State Board of Health makes the following statement and recommendation:

"The information available to the board shows that the sewerage and drainage of these districts [the Stony Brook and Charles River drainage areas] is inadequate and unsystematic, and, unless a practicable and adequate plan for the collection and proper disposal of the sewage, rain water and other drainage of these districts shall be devised and intelligently carried out in the future, objectionable conditions resulting from the present faulty sewerage and drainage systems will inevitably grow worse.

"The board would recommend that an investigation be made and plans prepared for the adequate sewerage and drainage of the Stony Brook Valley and the districts adjacent to the Charles River in the city of Boston."

The legislature subsequently passed an act which provides that during the next five years the city of Boston shall expend a sum amounting to somewhat more than $600 000 yearly in separating the sewage from the storm water in the valley of Stony Brook and the districts tributary to the Charles River, for the purpose of preventing the pollution of those waters.

The only practicable way of preventing the gross pollution of the Stony Brook channels and the Charles River into which they flow is the separation of the sewage from the storm water throughout those districts, and this is the most pressing of the improvements that are necessary in the sewerage of the city of Boston at the present time. The rebuilding of the sewerage system in the valley of Stony Brook and the Charles River, with the carrying out of other necessary sewerage works, will absorb all the funds which the city, in its present financial condition, is likely to be able to spare for several years to come. But the construction of these works is of far more pressing importance in the improvement of sanitary conditions in the Metropolitan district than any question of further treatment of the sewage discharged at Moon Island or at any of the other outlets in Boston harbor.

In other words, the problem is not at the outlet at Moon Island; it is in the inner harbor and in waters adjacent to the

inner harbor. The examinations of two years ago, as I have said, showed that the worst conditions were found in the inner harbor. The question of the filling up of the harbor, to which reference has been made by a witness before a commission at a hearing in Boston the other day, and in various newspapers, was very thoroughly settled in 1901 and 1902 by the investigation and report on the construction of the dam in Charles River. In the course of those investigations careful measurements were made of currents in Boston harbor, and soundings were made. Furthermore, all the available soundings made in the various years, beginning sixty or seventy years ago and coming down to the present time, were compared, and no definite evidence was found of shoaling anywhere in the harbor except in the inner harbor, where it was due to various causes, much of it to shipping.

The objectionable effect upon the harbor of the sewage discharged at Moon Island at present is less than the effect of that discharged at other points. The sewers in the cities of Boston, Cambridge, Somerville and Chelsea are constructed chiefly upon the combined plan and are designed to remove both the sewage and the storm water due to rain and melting snow. The intercepting sewers which convey this sewage to the three main harbor outlets at Moon Island, Deer Island and Peddock's Island are designed to take only the dry weather flow of the sewers of those cities, together with a small quantity of rainfall, estimated, in the case of the Boston sewers, to amount to about one quarter of an inch per day.

At times of rain, or when snow is melting rapidly, a part, and sometimes the greater part, of the mingled sewage and storm water of these cities is discharged through temporary overflow outlets into the waters of Boston harbor and its tributaries. Not only is a part of the mingled sewage and storm water allowed to overflow into the harbor at times of storm, but in the case of the city of Boston special effort is made to provide for the drainage of certain low sections of the city and prevent the flooding of streets and the basements of buildings by allowing a free connection through which the storm water may enter the intercepting sewers from such districts at times of storm to the exclusion of mingled sewage and storm water from other districts.

It thus happens that sometimes for days together large quantities of sewage are discharged through overflow outlets directly into the harbor or its tributaries. When it is realized that the total number of such overflow outlets is, at the present

time, more than two hundred, the impracticability of any plan of disinfecting the sewage discharged into the harbor will be readily understood.

The statement has been made that there is a limit to the quantity of sewage that Boston harbor can receive, and that in consequence the sewage of the town of Wellesley has been excluded. The real fact of the case is that there must be some limit to the quantity of sewage discharged into Boston harbor, though that limit has not been reached. There have been schemes in the legislature for discharging the sewage even of Worcester into Boston harbor. In 1900, by direction of the legislature, the State Board of Health, in an investigation relating to a proposed high level sewer, suggested a limit beyond which it was unnecessary to take sewage into Boston harbor, and Wellesley is beyond that limit. The town of Wellesley can dispose of its sewage at less expense within its own territory than it can in connection with the Metropolitan system. Moreover, the expense to the Metropolitan District of including Wellesley in the Metropolitan sewerage system would be greater than Wellesley's contribution to the support of that system under existing conditions.

It is likely, from present indications, to be many years before treatment of the sewage discharged into Boston harbor from the main outlets of sewers there will become a question for serious consideration.

PROF. WILLIAM T. SEDGWICK.* — I am glad to be present this evening and to share with Professors Winslow and Phelps great pleasure at the interest displayed in this work in which we have all been so much interested ourselves. I may say just a word or two about the general scheme of the sewage station, particularly as connected with an educational institution.

We were given $5 000 a year, several years ago, by an anonymous donor who had been moved by a belief that the harbor was being very seriously polluted and who was persuaded that more ought to be done than had yet been done toward the treatment of the sewage of large cities. The donor had no very definite ideas as to procedure, but believed that an educational institution like the Institute of Technology ought to be able to take up a problem of this kind and contribute to its solution.

It was pointed out by us to the donor that the State Board

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of Health had already done a large amount of able and pioneer work along these lines, but of course no educational establishment has the right to refuse a gift of $5 000 a year for experimentation in science if it can help it, so we set to work to make as good use as we could of this moderate sum. I think you will agree with me that we have already learned and done something.

The opinion that Boston harbor is going to the bad has lately found expression in newspaper statements, and through a witness before a recent commisson hearing, to the effect that it is filling up with great rapidity; so much so in fact that newspapers outside of Boston have touched upon the subject and have wondered that so intelligent a city as Boston is supposed to be, in a state as advanced in sanitary measures as Massachusetts has always been, should be content to allow this thing to go on. Now, of course, the real explanation is, as it was in the old story, — the boy lied. That is to say, the harbor is not sludging up in the way in which it was said to be filling, because Mr. Goodnough's very careful examination of 1900 and 1905 did not disclose anything of the kind. Besides, the federal authorities are constantly observing conditions in the harbor with jealous eyes lest sludging up should be impeding navigation, while our own state Harbor and Land Commissioners are expressly charged by statute to have a care that no unauthorized encroachments are allowed to interfere with the natural conditions of our harbors. And, as you know, we have a good Harbor and Land Commission, with a competent engineer in charge. We may, therefore, dismiss at once any fear that the harbor is rapidly filling up with material settled out from sewage. There is a pretty good circulation in the harbor which takes out much of whatever accumulates, more particularly during heavy storms. But at the same time we cannot look with equanimity upon the increasing discharge of sewage, as such, into the harbor, because we must realize that the time will come when the harbor will be seriously polluted, and perhaps spoiled, for pleasure purposes. In fact, Mr. Goodnough's report shows that the *waters* of the harbor are already seriously polluted, — so much so that harbor shellfish are no longer safe for use. Now, from any high standpoint,— from the standpoints of the public health and of the general welfare of a great seaboard city, with hundreds of thousands dwelling along its shores,— the sanitary condition of a harbor like this is a matter of very great moment.

The purity of Boston harbor is a very precious possession to the people of this neighborhood. The existence of the harbor

originally determined the situation, and its unrestricted use has ever since largely determined the welfare of Boston and the cities and towns in its immediate vicinity. The population dwelling upon its shores ought to be able to look forward to a larger and more wholesome use of the harbor rather than to a diminished and more dangerous use of it. For as population accumulates upon the land, the harbor, especially in the summer time, should forever remain, and ought still more to become, a playground as it were for the people; and even if sewage deposits do not greatly multiply, as there is reason to believe that they may not, yet boating will increase and fishing and bathing will go on, and if these cheap and wholesome entertainments are cut off, and if typhoid is brought back from the harbor or along the shores and planted among the people, Boston will suffer, and will continue to have a higher typhoid than any city ought to have.

Many explanations have been sought for the comparatively high typhoid of American cities, and we have found some of the explanations in oyster pollution, and some in our carelessness about water supplies. I daresay that some typhoid may come from cases brought by bathers and secondary cases given by them to their neighbors. But whether this be so or not, Boston harbor is a wonderful inheritance and a precious, a priceless possession to the people of this neighborhood, and no one can look with tolerance upon the idea that it is going to be spoiled or so seriously polluted in the future as to be unavailable for cheap and desirable recreation purposes. The time must come when something will have to be done with the sewage better than is now done; and the work at Lawrence, and the work at Columbus, and the work at Baltimore, and especially the work we have been doing in Boston upon this local problem, ought to contribute materially to the solution of that problem and to the ultimate conservation of the harbor.

We believe that our work does tend in this direction, and although a good deal of time and a good deal of money have been spent, we believe that the end which has been reached is thus far satisfactory. It is probably not final. New methods of purification will perhaps arise and more economic plans for sewage treatment. But something surely must and can be done in this direction.

Our work upon the *disinfection* of sewage and sewage effluents during the last few years is particularly novel, interesting and hopeful. It seems now entirely possible to protect the waters of our harbors and possibly of some of our rivers in ways

that we did not anticipate five years ago. And such disinfection, when combined with a reasonable organic purification, promises much from the sanitary as well as from the engineering standpoint.

You can readily see how very valuable this sort of work is to students, — to have a demonstration of work of this kind going on within easy reach of the Institute laboratories, — so that our young sanitary engineers and our young civil engineers and our young sanitary biologists and sanitary chemists can actually come into personal contact with such experiments, can see and appreciate these big municipal problems, and can get, themselves, a chance to do some little piece of work in connection with some portion of a great scheme. All this means, of course, a very valuable educational asset. We are particularly proud that our Institute has been able to do this work, and I believe I am within the truth in saying that it is the only educational institution in the world which has an establishment of this kind, operated under such favorable conditions, and offering such opportunities to young scientific men and engineers.

But to return to the point where I started, let me say that we are all greatly pleased that this Sanitary Section has seen fit to listen to our paper and that you have turned out in such goodly numbers to hear it. If now you will give us your perfectly frank criticism we shall value that even more highly. We know very well that there is room for it and we shall appreciate your criticism even more than praise.

Mr. R. S. Weston. — Mr. President, I understood Professor Winslow to say that the currents in the harbor are sufficient at all times to dispose of the suspended matter, in the effluent from the trickling filter, and I should like to ask whether that is in accord with the general belief that the current at the bottom or near the bottom of the harbor is very sluggish.

Professor Winslow. — I based my opinion on the investigations of the State Board of Health in regard to present conditions, which I understand indicate that there is no serious accumulation taking place. The effect would be the same with the trickling effluent; that is, there would be neither increase nor decrease of the problem as regards suspended solids. I have never seen any evidence and have never heard any evidence of a sound character to the effect that there was appreciable sludging up of the harbor due to sewage at present.

Mr. E. S. Dorr. — One thing occurs to me to ask Mr. Winslow, and that is, whether his experiments wouldn't lead him to

believe that a simple economical treatment of crude sewage, enough to effect a practical sterilization, with the under water discharge, wouldn't be sufficient for the present and for quite a period in the future; that is, whether it would not effect a very material improvement over the present discharge and practically be sufficient, without going to the expense of building trickling beds, which seem to be out of the power of the city financially to accomplish at present.

Professor Winslow. It is, of course, entirely impossible for us to say what the city can or cannot do in these premises. But I am very glad that Mr. Goodnough has brought out other phases of the situation and laid emphasis on them. We appreciate fully that the Moon Island outlet is only a part of the larger problem of Boston harbor. It is important to do the biggest things first, whichever those may be. We have only considered the Moon Island outlet because that was the particular problem given to us to study. At that outlet, I believe, it will ultimately be necessary to bring about the complete purification of the sewage; I mean purification, both organic and bacterial. By ultimately, I don't mean this year or next year, or even five years hence, perhaps. Ultimately I think we shall have to take both organic matter and bacteria out of Boston harbor, but I think, of the two, probably bacterial purification is the more important. As we pointed out in the paper, Professor Phelps and I believe this can be effected at a cost of $110 000 a year approximately, while complete purification will cost $250 000 a year. Which of those two plans, if either, the city of Boston is able to adopt at present, or will be able to adopt in the near future, is a question which we cannot presume to decide. Chemical disinfection will remove bacterial pollution at Moon Island. We have suggested that chemical treatment alone is feasible before the other plan is taken up. I don't believe, however, that chemical treatment alone will be a complete solution of the difficulty. Some time we shall have to demand organic as well as bacterial purification.

Mr. W. S. Johnson. — It seems to me that this paper is a distinct contribution to our knowledge of the subject of sewage disposal. It is particularly interesting to note that the results of the experiments made at Boston and with Boston sewage differ so greatly in many respects from the results of careful experiments at other places and with different sewages, showing the absolute necessity of a thorough knowledge of the sewage to be dealt with. The conclusions with regard to the septic tank, for

example, differ greatly from the conclusions at Columbus. The Massachusetts State Board of Health has many times been criticised for its attitude in regard to the use of the septic tank in Massachusetts, but it would certainly seem from the results of these experiments, and from the results in other places in this vicinity where the septic tank has been tried, that the board has done a great service in preventing the general introduction of septic tanks in Massachusetts.

Prof. E. B. Phelps. — It has occurred to me that perhaps a word about this suspended organic matter which is prominent in this discussion might not be out of place. If any of you should come to our station and see some of those effluents side by side with the crude sewage in bottles I doubt very much whether you could pick out the effluents. In appearance, at least, you could not tell them apart. If you smelled them you'd find the effluent was sweet smelling and could readily be distinguished from the sewage. The fact is that the effluent contains about as much suspended matter as does the sewage, and to the sight it is not improved. That fact is the very salvation of this process. Contact filters, we have learned, are going to fill up. And there has been some question about the permanency of the trickling filters. But the very fact that trickling filters give out as much suspended matter as they take in seems to be their salvation, and we have every reason to believe, after two years of close watching of these filters, that under local conditions and with the problem in hand, these filters are reasonably permanent and will not be liable to any serious clogging.

Now one is apt to get an erroneous impression if you let the matter rest there. You have got to distinguish between those two kinds of organic matter. I want to emphasize the fact that the suspended matter that comes out is not in any sense the same material that goes in. It is altogether a different thing. It is not the same stuff. And that is particularly illustrated by the fact that during a portion of the year we stored some of that material in the filters and at the end of several months the suspended matter coming out was in excess of that which went in. We have considered somewhat superficially the question of disinfection of crude sewage. That did not appeal to us at first. It is beginning to appeal to us more and more, and we are quite satisfied now that there may be places and conditions where disinfection of crude sewage is called for and where that alone would be sufficient. Our experiments are rather meager on that particular point. We have been pretty thorough on the other

matter of effluents. The experiments that we have carried out have indicated the necessity for about twice as much chlorin in the former case as is called for in the latter. It is the organic matter in the sewage which uses up this chlorin before it can get in its work as a disinfectant. We have carried out some work in New Jersey, at the town of Red Bank. We have been disinfecting septic sewage there all summer, and the septic sewage seems to be still more oxidizable and uses up even more chlorin than does crude sewage.

It has been my good fortune during the past year or two to have been more or less closely associated with the work in other Eastern seaboard states, and it is possible that their experience may furnish some indication of the future needs of Boston. Baltimore is now building one of the finest systems of separate sewers and drains in the country. By legislative enactment it is provided that sewage should not be discharged from Baltimore into the waters of the harbor or Chesapeake Bay until it has been purified to the highest possible degree.

As a result the sewage commission of that city through its chief engineer, Mr. Calvin Hendricks, is now making an elaborate study of purification processes and is considering the matter of disinfection.

By a mutual agreement between the authorities of New Jersey and Pennsylvania, steps are being taken on both sides of the Delaware toward the cleaning up of that tidal water. The cities of Camden and Trenton on one side and Philadelphia on the other have each been notified that within a certain limited time sewage purification works must be installed. The New Jersey cities have been given four years, and Philadelphia a somewhat longer time in which to prepare plans.

In New York a commission has, for the past three years, been investigating the condition of New York harbor. It is generally conceded that some steps must soon be taken there. One of the consulting experts of that commission told the speaker but recently that, in his opinion, disinfection was a feasible and the most practical solution of their problem. In addition to the work on the lower Delaware, New Jersey has adopted a policy of rigidly excluding sewage from its ocean front and tidal waters.

It is thus plain that our work is neither academic nor untimely, but simply well in line with what is being done and thought out in other states, and for other great seaboard cities.

A Member. — I noticed that Professor Winslow said his

trickling filters were 8 feet deep. I would like to ask him how much additional head was taken by the trickling device.

Professor Winslow. — Either of the sprinkling devices will work satisfactorily with a 4-ft. head over the surface of the filter, but will work still better with a 6-ft. head when that is possible. Incidentally I may say that the depth of 8 ft. allowed for our filters was probably excessive. We have made our estimates on the basis of 8-ft. beds and 4-ft. head over them, but in the next two years we hope to find out whether a 5-foot bed will not work equally well. Experiments made on our old filters by taking samples at different depths indicate that a less depth than 8 feet is quite satisfactory. But we don't feel it is quite safe to make that conclusion definitely as yet.

Mr. George A. Carpenter. — There is one point upon which I am not quite clear. In his paper I think Professer Winslow referred to his screening as at present carried on as through bars about four inches apart, and I understood him to say later in the paper that he thought screening through a finer screen more desirable. I wanted to ask Professor Winslow how fine a screen he thought would be most advantageous, and whether his experiment led him to believe that the greater amount of matter that could be taken out in that way, thus relieving the trickling filters, the better.

Professor Winslow. — I should have said that the bars were ½ in. apart in our experiments. I spoke of more careful screening, in comparison with the present system, not at our experimental station, but at the Dorchestor pumping plant. I don't think I should be prepared to say just what size screens are necessary in this case. Our idea is to remove large floating particles and inorganic solids, street dirt, etc., but not to remove the finely suspended organic matter in the sewage.

A Member. — What is the practical working out of this process of adding a disinfectant to the sewage? If it was on a larger scale, would it be necessary to have auxiliary tanks or anything of that sort to apply this to the effluent?

Professor Winslow. — In this particular case it would not be necessary, because the disinfectant could be applied at Thompson's Island and would be thoroughly mixed by the time it reached Moon Island and could then have an additional storage period in the existing tanks at Moon Island.

[Note.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 16, 1908, for publication in a subsequent number of the Journal.]

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THE POLLUTION OF WATERS AT COMMON LAW AND UNDER STATUTES.

BY CHARLES F. CHOATE, JR., ESQ.

[Read before the Sanitary Section of the Boston Society of Civil Engineers, December 4, 1907.]

Mr. Chairman and Gentlemen: I want to thank you for the compliment you have extended to me in asking me to speak to you to-night. I assure you that I appreciate it. As I look about this board and see the faces of men whom I know have been through great fights with men like Mr. Goulding and Mr. Pillsbury and Judge Bumpus and Mr. Morse and others of that class, I need not tell you that I feel diffident in attempting to discuss before you those principles of law which must have been involved in nearly all of the work that it has fallen to your share to do. While diffident, however, I was not unwilling to attempt the task of some discussion, because I am a beginner at it and interested in it. I might illustrate my position, if you will permit me, by a story. You may have heard the story of the Scotch gamekeeper. If you have not, I will tell it to you.

One of our criminal rich,—of whom the number is growing less and less, and who will soon, probably, be extinct,—while in possession of a considerable amount of predatory wealth, was fortunate enough to be able to lease a shooting estate in Scotland, and hired a Scotch gamekeeper. He noticed that the gamekeeper always wore a hat or cap that pulled down over his ears. He never felt particularly like inquiring why he wore it, but still it attracted his attention and aroused his curiosity. On returning the next season he found his gamekeeper there but without

the cap. Instead of the old cap that he had pulled down over his ears, he found him wearing a little dickey that just perched upon the top of his head. He said, "Why, Sandy, that is a peculiar kind of hat. What has become of your old cap?" And the gamekeeper said, "Well, I haven't worn that since the accident." "Accident?" said the man. "I didn't know that you had met with an accident." "Have you not heard?" said Sandy. "Well, it's this way. One of my friends asked me to have a drop to drink and I didn't hear him."

Well, now, I feel an additional embarrassment in speaking to you to-night on this subject because I see upon my left a most generous opponent in some litigation in which I have recently been engaged, and upon my right the representative of the attorney-general's office, and I want to premise any remarks I make with this stipulation, that nothing that I say to-night shall be taken as an admission in any proceedings in which I may be involved hereafter.

Now, I was told since I came here that it was understood the subject upon which I was to speak was expert testimony. But I hope you gentlemen didn't think I had the temerity in this audience to speak upon that. The subject which I had selected at the suggestion of your chairman, it may be a paradox to say, is possibly a dry one, but it seemed to me that it naturally fell into principal divisions: first, the pollution of fresh waters, which is always capable of one or more subdivisions; and secondly, the pollution of tidal or salt waters, ocean waters.

Now, with reference to fresh waters. Of course those problems which we have to deal with involve, first, running waters, rivers or streams navigable and non-navigable, as to which the rights and liabilities are slightly different; and, secondly, ponds, private or great ponds. By great ponds I mean those which by law are so classed — ponds about or exceeding 10 acres in area, which by law are known as great ponds and which by an old ordinance of the colonies were made the property of the state, the Commonwealth. And dealing first with the common law with reference to the rights of individuals and municipalities in running waters, I think the law can be generally stated as it has been stated, fortunately for us, in a recent case decided by our Supreme Court, the case of Parker against the American Woolen Company. That was a case which involved the question of which Mr. Safford has just spoken — the pollution of a running stream, a non-navigable stream, by mill wastes. And the whole question and all the authorities in this

country and abroad touching the rights of mill owners to discharge mill waste into running waters, and the rights of riparian owners below to prevent that discharge, were discussed and settled.

Very briefly stated, the rule the court laid down in that case was this: that every riparian owner — and by riparian owner you will understand I mean an owner of land bordering upon a running stream — every riparian owner had the right as an incident to his ownership of land bordering upon a running stream to have the water come to him in its natural flow unpolluted except by a reasonable use of it by others. As an owner of that land bordering upon the stream, he possessed the right to make a reasonable use of the water. Every other man who owned land bordering upon the stream had the same right. The existence of that same right in all individuals who owned land necessarily, sooner or later, brought them, in the exercise of their rights, or would bring them, in the exercise of their rights, in conflict with each other. And there the law enforces something in the nature of a compromise and establishes the principle that every man can use the waters of a running stream in the exercise of his own rights, but subject to the limitations that in the exercise of those rights he shall not interfere with the rights of other individuals. That is not at first blush an illuminating definition.

But possibly illustration makes it plainer exactly what the court means. The law on this particular point is probably the oldest and best-developed of any portions of law which deal with this subject of rights in waters and the invasion of those rights. And from early times a man who owned land bordering upon a stream was held to have the right to use the waters of that stream for reasonable domestic purposes — for washing, watering his cattle, irrigating his land, bathing, fishing and for such things as were incident to the ordinary domestic occupation of land; always, however, subject to the limitation that he should not substantially or appreciably diminish the flow of water by what he used for irrigation purposes, and that he should not to any appreciable extent introduce into that stream by his use of it any noxious or improper or unhealthful substances.

Now you will see, starting with the domestic uses, that introduction of noxious substances into water might continue in the less thickly settled districts almost indefinitely in point of time without appreciably affecting the quality or the quantity of water in the stream. Mere bathing, mere watering of cattle

in a stream, probably domestic washing, fishing of course,—many of those things which would now instantly and properly be prohibited in public water supplies, would be regarded as not appreciably affecting the quality of the stream, the self-purifying principle in every such stream of water being considered sufficient to prevent anything of serious consequence from following.

The right has always existed, and is possessed and has been possessed by an owner of land bordering upon a stream, either to sue for damages if the quality or the quantity of the water in the stream has been affected by an upper owner, or to go into a court of equity and obtain an injunction. But you will notice in contrast with what I want to call to your attention later that the law has confined itself — the common law has confined itself—to the protection of property rights as distinguished particularly from those measures which would protect the public health or prevent the creation of a public nuisance.

Many instances have arisen which have tested this principle which the courts have laid down in ways which have raised difficulties for the courts. For instance, the erection of a saw mill has usually been followed by the turning of sawdust into the river. The question has been presented to the courts as to whether that is a reasonable use to make of the stream. It is a discharge of a waste, not noxious in itself, but might become so if used to an unreasonable extent, and may appreciably affect not only the flow, but the quality of the water. Usually, however, that has occurred in localities which have been thinly settled. Naturally we find the lumber mills in thinly settled districts, and it has not, therefore, been difficult for the court to say that for such regions as that such a use was not an unreasonable use. And the principle is always to be applied and always is applied by our courts with reference to all the surrounding circumstances of the cases involved.

A very recent case in Pennsylvania possibly strained that doctrine to its limit. The principle has been discussed here in Massachusetts, but has not really been accepted or rejected, and a case is never likely to arise here. In Pennsylvania some of the coal mine owners pumped the water from their mines and allowed that water to run down over the surface into a natural stream. Of course it ruined the quality of the water for domestic purposes. Probably with a desire to protect those interests, which were the prevailing interests in the state, the courts were led to hold that that was not an improper use, though upon principle it seemed to deprive every lower owner of every other

use of the stream except that use. It was practically a use for drainage purposes and practically prohibited any use of it for domestic purposes.

The same principles which the courts have adopted with reference to running streams and the same remedies are, of course, available to the owners of private ponds. I mean to limit that definition to those ponds which are wholly the subject of private ownership, and also to limit it to natural ponds. Of course, that is an exceedingly small class in number — ponds not 10 acres in area. With such ponds, you appreciate, there must be always some owner or owners of the whole, that is, of all the soil underneath the pond. It may be in one or more owners, but there must be owners of the soil underneath. If there are more than one, the rights of those several owners, I take it, would be exactly analogous to the rights of owners bordering along a running stream. Each would have the right to use the water probably for boating or bathing or fishing over that part of the bottom which belonged to him. Each would undoubtedly have the right to cut ice. Neither would have the right to discharge into that water any matter which would prevent his neighbor or adjoining owner from using the waters of the pond for such purposes, namely, for proper domestic purposes, as I have just described. Undoubtedly, the right would include the right to water cattle, though that might involve some pollution which would now be prohibited, or could be prohibited, by statute. At common law, undoubtedly, I think that would be a right incidental to the ownership of the land. The right to bathe, I think, unquestionably would be one the owner might enjoy.

Taking, then, next, the situation of great ponds, that is, ponds in area above 10 acres, we find this situation: In 1647 was passed what was called the Colonial Ordinance. There were many others, but this one has always been called *the* Colonial Ordinance. It provided that no town should be able to grant to any individuals any rights of ownership in ponds exceeding 10 acres in area, but that these ponds should be the property of the commonwealth and should be held always for the enjoyment of all the individuals of the commonwealth for fishing and fowling. And a curious provision follows to the effect that every individual should have a right of access over the lands of others to those ponds, providing only that in getting access he did not have to cross any man's meadow or corn land. Now that ordinance was repealed by the repeal of the Massachusetts

charter, that is, the Colonial charter. But our courts have held that the principle that was involved in it has become a part of the common law of this commonwealth. So that at common law those ponds in excess of 10 acres in area, unless granted before that time to individuals or to towns, became, and have been ever since, unless granted away since, the property of the commonwealth for those purposes. Whether the right still obtains to cross any other man's land to reach those ponds, provided you do not cross his meadow or corn land, the courts have never had occasion to decide. But it might be interesting for some of us to try that some time and raise the question.

The right of the public in those great ponds — and bear in mind I now speak of those only which remain the property of the commonwealth and have not been devoted to purposes of any public or municipal water supply — the rights of the public in those ponds, a member of the public, any one of us who can get access without raising any question of trespass, is to boat, to fish, to fowl, to skate, to cut ice; in short, to use those ponds in the exercise of that public right as an individual as distinguished from any right which he has as owner of land, or as anybody else to exercise those rights, providing that by so doing he does not interfere with the same rights which are vested in everybody else.

Of course, the existence of the right to do those things in others as well as the sort of stewardship of the commonwealth which holds those ponds, as it were, in trust for all of us citizens, involves this necessary conclusion: that no man in the exercise of his public right as an individual citizen of the commonwealth can do an act with reference to the waters of those ponds which would interfere with the enjoyment of the same rights in others. And upon that principle, of course, no one could turn sewage or any noxious substance into any great pond without immediately involving himself in a controversy with the commonwealth. I take it that the law is reasonably plain that the remedy is not invested in other individuals of the public here, but is invested in the commonwealth and would have to be enforced by the commonwealth's law officer, the attorney-general. You have in mind, doubtless, that principle of law which is to the effect that the private individual has no remedy, no personal remedy, for a public nuisance; that is, for the invasion of a public right. If, for instance, on leaving the club and going home we find some man without license has dug a trench across the street which obliges us to go around, or put

up a barrier in the street which obliges us to go around, none of us has any private action against him, that being a public nuisance which is an invasion of the rights of the commonwealth, and those rights must be enforced against him by the proper law officers of the commonwealth. But none of us, as an individual, has any private remedy or any right to recover damages.

So, with reference to a great pond, if we were deprived of our right, by pollution of its waters, of its use for bathing or boating or fishing, none of us would have a private right to recover and would have to seek enforcement of our rights through the law officer of the commonwealth.

Probably the most interesting aspect of this question of pollution arises out of the relations to it of municipalities —those questions which involve the right of towns or cities to turn drainage or sewage of any kind into running streams. Now this principle seems to be established beyond any question that the drainage of streets in towns or cities in a natural watershed of the stream may be turned into that running stream without anybody's having any right to stop it or to recover any damage for it. You see in substance what that is is only collecting in your street gutters and drains the natural rainfall on a given area, and discharging it more quickly than under natural conditions it would have been discharged into the same drainage outlet. So far as the operations of the municipality are confined to that they are lawful. The mere fact that the discharge is rendered quicker and perhaps greater by the fact that the water as it falls is collected in gutters and drains, and discharged without opportunity to evaporate or soak into the ground, even with the collection of matter in the streets and on the surface of the streets into the running stream, is not a violation of the rights of any riparian owner below. But the right to discharge the sewage of a city into a stream is quite a different matter. And that has to be viewed from two aspects.

An old case which may be familiar to some of you here, and which is often cited as authority, was a suit brought by a man named Merrifield against the city of Worcester. Worcester had discharged sewage into Mill Brook for some years without authority of statute, and Merrifield brought an action to recover damages against the city for injuries to his property below on the stream because of that discharge. The court in the case decided that the city was not liable in damages because of that act, but that decision would be nothing more than this, that in

an action of that kind a city, which is a creature of the statutes passed by the legislature, and can act only by authority of the legislature through its charter, cannot be held liable to pay money damages because of such an act of the city. But quite a different consequence would have followed had Merrifield in that proceeding adopted a different course. I take it if, instead of seeking to recover damages, he had gone to a court of equity and had shown that this injury resulting from turning sewage into the stream which flowed by his land was a continuing injury, a detriment to that property, and was not warranted by any statutes giving the city of Worcester the right to maintain it, he could have obtained an injunction against the city and have prevented the continuance of that pollution. So that I think I may fairly state that, short of such a case as I shall speak of in a minute, any individual who owns property on a running stream can prevent the pollution of that stream, whether it is caused by an individual or a set of individuals in the shape of a corporation or a municipal corporation, unless that pollution has been continued for a period of more than twenty years, so that a right has grown, or unless it is authorized by special statute.

Taking those questions which occur to me now as raised by Mr. Safford's introductory remarks — the cases that arise from the discharge of manufacturing wastes into running streams — it must necessarily follow from the principles which I have already called to your attention, and which I think our courts have laid down quite strongly and are ready to stand by, that it is of no consequence what the character of the substance discharged into the stream is if the result is that substantial and appreciable pollution occurs, whether that be so exceedingly noxious a substance as city sewage, or whether it be a substance like acids, or waste from a paper mill, or wool scourings from a woolen mill — those things which appreciably change the character of the water in a running stream are unlawful and can be prohibited by our courts. And they can be prohibited whether done by an individual or a private corporation or a public corporation. The only right to pollute water which can be obtained, and which is recognized as a right, is granted by statute, and I take it must involve the payment of damages for harm done, or a right which is acquired by prescription, as it is called, that is, by the use for twenty years under a claim of right without anybody's objecting to it, just as you can get a right of way across any man's land.

You notice still that all these questions I have been asking your attention to involve property rights, except, possibly, that which involves the rights of individual members of the public in great ponds. Passing from that division of the subject for a moment, let me ask your attention to another division of it which I think has been less discussed heretofore either among engineers or among lawyers than the one of which I have just been speaking; and that is the pollution of tidal waters. That must be a question which is going to engage engineers as well as lawyers very closely in coming years. And it is going to be a very large and serious question, it seems to me. Now here are immense sewers constructed and being constructed throughout the state, collecting sewage from all the larger cities and towns and discharging it into the harbor or not very far from the harbor and a great many private properties. There has been in this city and many other cities, noticeably in New York, a system of garbage disposal which sooner or later is going to attract the attention not only of engineers, but of lawyers. Pretty soon people who begin to feel the effects of those things are going to inquire of the lawyers what rights they have.

Now I take it there is this distinction between the right to have your tidal or seawater free from pollution and the right to have running water in streams or ponds free from pollution: Every man who owns land bordering on a stream possesses a property right, a right to have the water kept free from pollution, which is a right incident to his ownership of the land. It is not so with reference to the right to have one's ocean water kept free from pollution. The same ordinance that I spoke of a few moments ago, the ordinance of 1647, extended the ownership of every individual who owned land along the seashore from high-water mark, where before that time the law had placed it to mean low water. That is, it gave to the owner adjoining all the land which lay between high water and mean low water, that is, all the land in effect that is covered by the ebb and flow of the tide. Beyond that, beyond mean low water, the bottom is the property of the commonwealth, at least as far as we are interested in it. I won't say how far, but as far as we are interested. Now there is no ownership in the water. Everybody has a right to use the water for purposes of navigation or fishing or bathing if he can keep his feet off the bottom and not commit a trespass. If the tide is up, anybody can row or sail a boat in the water that stands over the flats which extend from high water to mean low water. But nobody can go there when the tide is out without committing a trespass.

Now, how does that leave the owner of property bordering on the sea if either an individual or a municipality insists upon turning sewage or dumping garbage into those waters in such a way as to become a nuisance or to create a stench upon that property? And every one of you probably knows numberless instances where that is done without thinking. Many of our citizens who own seashore property have run their house drains down into the sea. And here are all the large cities turning their sewage into the sea not a great distance from the shore. This is particularly noticeable along the Jersey coast and at Staten Island in New York, where solid material from the sewage is constantly coming ashore. While no man can have a private action for damage unless he can show actual injury to his property, I take it that there is no question that if the offense reaches the stage of being a public nuisance there is a remedy. That is, it can be prevented. On that question of sewage our courts have already decided in the suit of Haskell against New Bedford that if the city turns sewage into New Bedford harbor and fills up a dock by accumulations deposited there, the owner of that dock has a right of action against the city and can enjoin it from pursuing that course. The same principle must be involved in those suits in which, I trust, all of you and myself may hereafter be engaged, which will be brought by those people affected by the sewage of the great cities of the future, which will not only affect the lands fronting upon the sea, but must, unless some different method of disposal is devised, reach the stage of a public nuisance.

I have spoken so far only of those rights and remedies which exist at common law, and I mean now, before sitting down, to say a few words relative to that valuable supplement of the common law, the statute enactments, which one considering the question as left by the common law sees are absolutely necessary. I have called your attention to the fact that all the common law has undertaken to deal with has been property rights. It has not dealt in any practical way with the condition which menaces the public health, though I am not suggesting that under certain circumstances it might not. But for all practical purposes the development of the law has been in the direction of the protection of property rights. Now, as the waters of streams or ponds come to be used for the purpose of a public supply, there is a vast other different interest from the property interest which has got to be protected, and which can only be protected, sufficiently protected, by statute enactments. For instance,

this city takes a great pond for water supply, like Lake Cochituate. The question immediately arises whether the residents of that neighborhood have still the rights to boat and to bathe and to fish in that lake. The guardians of the supply believe it is not safe to permit the indulgence of that right. If they have got to resort to the somewhat slow method of the common law to obtain redress, or to prevent individuals from indulging in those rights, the public health may be seriously menaced meantime. For cases such as that you will see a statute is necessary, directly to prohibit, in waters used for water supply, the indulgence of those rights or privileges which are possessed by an individual or a land owner at common law, and to provide a method of speedy enforcement; and for this purpose the statutes have given us the aid of criminal law for the purpose of protecting the public health. Now, in two ways that has been done, either by passing laws directly forbidding the doing of certain acts with reference to the waters themselves, or investing in certain boards, as the State Board of Health and the Metropolitan Water and Sewerage Board, the right to make and enforce regulations with reference to bodies of water used for purposes of water supply. A very interesting question was raised and argued at the last sitting of our Supreme Court as to whether there existed in a natural pond, a great pond like Lake Cochituate, which had been taken and used for purposes of water supply, the right to boat upon that pond when the body in whom had been invested the guardianship of those waters for a section of the people of the commonwealth had prohibited such a use. And the court held that such regulations were valid and that in the face of them the former existing public right or individual right to boat and bathe in waters of great ponds had been lost.

I am going to take the liberty for a moment before I sit down of departing from that subject to suggest two rather interesting questions which have come up, and which I thought might interest you from an engineering point of view, and which have been dealt with by the courts. They relate to waters, though not strictly to the sanitary end of the subject. One was raised in a case recently tried in Worcester and involved this question: A man owned a water privilege on a river. Above him were four or five other privileges, and by privileges I mean reservoirs where there was power developed. For many years it had been the practice of all the owners of privileges upon that stream to run their mills in the day time, say for eight or nine or ten hours a day, and to let the water down during the hours

of daylight and store it up again at night. By and by one of those upper owners began to manufacture paper and also to manufacture electric light, so that it became a business proposition for him to use the water on the stream every hour of the twenty-four, and instead of storing it up over night, as a result of which lower mill owners would get the benefit, he used the water all the 24 hours and there was no accumulating storage. The lower mill owner brought an action against him to compel him to hold the water up at night, as had been the practice for many years — I'd almost say for generations of mill owners — and immediately the question was presented whether, the custom apparently having been adopted and practiced for many years, one mill owner could depart from it to the detriment of another, or whether he was bound by that custom and must, for the advantage of those below him, abide by it. And the court went back to the old principle which I have attempted to enunciate, that every man was entitled to have the water of a running stream come to him in its natural state, and that meant it was to run all the 24 hours and if it was dammed up by anybody, that was something of which you got the benefit; but if he chose to run it all the 24 hours you, by law, could not complain.

Another substantially new principle was raised in a case which I had the pleasure of trying, with Mr. Safford's assistance, and that was as to the right of a man who owned a privilege down stream, with two or three or half a dozen privileges up above, and whose privilege was taken, that is, seized, by the city or town, which had the right to do it, whether he was entitled to ask the courts to assess his damages at a greater amount because of the advantages he derived from his position on the stream from the storage of owners farther up. It being established by a decision of the court of which I first spoke that he had no right to require the upper owners to keep their dams up, the question was presented, had he a right to recover damages despite the fact that he could not make the upper owners keep their dams up, because his property, being lower down the stream, did possess the gratuitous and incidental advantages of making use of that storage as it was let down to him. The analogy was suggested, a building on this street. It has value because all around it there is business property and dwelling property. It is valuable because it has been selected as a locality in which people have and in all probability will continue to have business interests. And yet the owner of this property could not compel the owner of any of this adjoining property to use it for any specific

purpose, or to maintain any kind of building, or to continue to devote it to business or dwelling-house uses. Yet the principle must be plain that, inasmuch as this property will, in all probability, continue to be in the center of business activity, and the region around it will be devoted to those purposes, despite the fact that you have not the valid right to keep it so, there is unquestionably a value growing from those facts, to which you have not an absolute right, which gives to your property an added value, which has to be taken into consideration if it is taken away from you. And I am happy to say that the court sustains that proposition. I thank you very much, gentlemen.

DISCUSSION.

A MEMBER. — I would like to ask if the statutes have not changed the law regarding the acquiring of a right by prescription?

MR. CHOATE. — That is true in reference to the commonwealth. Between the years 1835 and 1867 an individual, and I should say also a city, could acquire the right to pollute a great pond. In 1867 that law was repealed so that now no one can obtain the right of prescription against the interests of the commonwealth in its great ponds. There is no statute at the present time which prevents an individual from getting the right of prescription against another individual. That is, to illustrate, if you own higher up on the stream and I own lower down, and you turn your house drainage into that stream for twenty years, you can acquire a right against me. Further down that stream empties into a great pond which has become a water supply. In that case you might acquire the right against me, but could not now acquire it against the commonwealth.

A MEMBER. — Has not the statute changed the size of a great pond to 20 acres?

MR. CHOATE. — I did not know it. I may be wrong.

MR. ALEXANDER LINCOLN. — I was asked yesterday to join in the discussion of this subject and came prepared to say only a few words. My acquaintance with the subject has been gained by being connected with the case of which Mr. Choate has just spoken — Parker against the American Woolen Company — in which I was associated with Mr. Whipple in behalf of the American Woolen Company. They conduct a woolen mill on Beaver Brook, which runs into the Merrimac River. The mill is situated near Lowell, and Beaver Brook runs into the Merrimac near Lowell, so that the locality is one where the water is largely

used for mill purposes. The pollution complained of was the ordinary pollution one would expect from a woolen mill. There had been at various periods wool scourings dumped there and dye stuffs escaped into the river and compounds of different sorts and acids. That was practically conceded by the company, but the difficult principle involved was whether they had not the right to pollute to some extent, and, if so, to what extent?

During the course of preparing the case for argument before the Supreme Court, quite an extended search was made of authorities for the law on the subject, and on our part we became convinced that the rule which ought to be adopted by the Supreme Court was very different from the rule which they finally adopted. Of course the position taken by us upon the question was a partisan one. It was not an entirely impartial and scholarly investigation which we made, but was with the idea of taking one side rather than another. However, the rule of law which it seemed to us should be adopted was the rule which may be stated in general terms as applicable to the use of water by any proprietor of land on the water, that he and every other proprietor may make a reasonable use of the water of the stream as it flows by his land.

That rule has descended from the common law of England centuries ago. At that time the principal use made of water was for domestic purposes, the watering of cattle, for drinking purposes and possibly to some extent the damming of the water for mill purposes, but of course to no such extent as in this country at the present day. It is true the courts at that time also did say expressly that no person was allowed to pollute the water of the river, but that seemed to be more a particular application of the rule that each person might make a reasonable use of the river than an entirely independent rule. That is, the courts at that time, having regard to the development of the country and uses to which water might reasonably be put, announced as a fact that a use of the water which polluted the water was not a reasonable use.

Coming to this country, however, which was in a different state of development, the courts from an early day took a somewhat broader view of the situation. In a number of jurisdictions questions arose, principally from the depositing of waste from saw mills and other like cases, where such pollution of the water was permitted. There was a case in New Hampshire and a case in Minnesota and also the case of which Mr. Choate spoke in Pennsylvania, a mining district, where the court decided that

water might be polluted by acid which came from mines and was emptied into the stream, that being a reasonable use of the water, having regard to the locality.

In Massachusetts the law appeared to be in rather a confused state. There were some decisions which announced the principle of the right to a reasonable use very strongly, and some in which it was applied where pollution in the form of deposit was permitted. In the case of Merrifield against Worcester, pollution in the form of sewage was permitted. Other cases in which it was said no pollution would be permitted were found. The general principle was announced by Chief Justice Shaw, who has a great reputation in the law, in terms which would be applicable to the pollution of a stream. He said: "In every case a riparian proprietor has a right to make a reasonable use of the stream which flows past his land." He further said that the question of a reasonable use is a question of fact; that is, a question to be settled ordinarily by a jury, and that in determining what is a reasonable use, the character of the stream should be considered, the character of the population, the density of the population along its banks, the wants and uses of the community; in a word, every question which would be considered in determining the question as to what the public policy of that particular community was or should be.

Those considerations were presented to the court. But the court decided in our case that no pollution is to be permitted which shall appreciably or noticeably affect the purity of the water with respect not only to manufacturing uses, but to domestic and even drinking uses.

Now it does not seem as if that was a very practical solution of the problem of the use of water for different purposes. At the present day no person wants to drink the water of any stream which he may come across. That should be regulated properly by statute or some commission; and, of course, in the large cities, the use of water for drinking purposes is regulated by commission. It seems to me that the manufacturing industries of the state should receive some protection and should be given some freedom of development and should be considered to be of more importance than the watering of cattle and agricultural uses which were formerly and may still be considered in some jurisdictions of paramount importance. But under the law as it stands, the use of water for mill purposes would seem to be considerably restricted. In many instances, as, for instance, the case of the conduct of woolen manufacture, it is

impossible so to conduct the manufacture that water shall not be polluted to some extent, so that if this rule is rigorously applied, it is hard to understand just how the manufacture of woolen goods can be carried on at all. In this case of Parker against the American Woolen Company the water cannot be entirely purified, although since that time a large set of filtration tanks and sedimentation basins has been constructed; but we understand that does not render the water of such a quality as to make it fit for drinking purposes.

There are two principal uses in such manufactures to which the waters are generally put. There is the use for carrying off waste — as a sort of sewer; and the use of the water for washing. It seems to me, particularly in the last respect, that it is very important that the land owner may be allowed to pollute the water to some extent, and unless he is given some freedom by statute it is rather difficult to see just where we shall end with regard to our manufactures.

Mr. Wheelwright. — I did not come here with anything prepared, but I have been very much interested in what has been said, having had a little experience in watching the pollution of streams and in trying to prevent it, and, I regret to say, not very successfully. I was much interested in what the previous speaker said in regard to the pollution of a stream by another manufacturer, because I have a similar case to deal with. There is a wool scouring mill above one of my paper mills which has been of great annoyance, and I feel they now recognize that we have some rights, and they have tried to remedy conditions, and from what I have heard to-night I am sure that my case against them is much stronger than I supposed it was.

The question of pollution is very puzzling, and one which every manufacturer must look upon as something which may come home to him, especially if he is located on the Neponset River. It is a question which, I think, the state will have to deal with as a whole, and establish some rules which have a greater measure of equity and justice in them than one seems likely to get at law.

Dr. L. P. Kinnicutt. — There has been a case recently tried in the Worcester courts that resembles the case of Parker against the American Woolen Company, only in this case the amount of pollution is much less than in the Parker case. The case I refer to is that of Honora McNamara *v.* David M. Taft. Mr. Taft owns a small mill in the town of Oxford for the manufacture of shoddy, which is situated on a small stream that flows

through pasture land owned by the plaintiff. The plaintiff's house and barn are not situated on the stream. The plaintiff claimed that the cattle, which, by the way, consisted of three cows, when in the pasture would not drink freely of the water on account of its being polluted by the waste products from the Taft mill, and asked for an injunction and damages. At the Taft shoddy mill no wool washing is done, and the waste from the mill consists principally of dyes, washed out from the goods after they have been speck-dyed. The testimony in the case was that the water in the stream as it flowed through the pasture was as free from color, taste and odor as some of the potable waters of Massachusetts, and neither chemical nor bacteriological examination gave any evidence of marked pollution. And, further, there was only very little difference between the character of the water at the dam before it passed through the mill and as it flowed through the pasture. The judge in his written opinion said that on visiting the stream he was unable to detect any difference in the color, taste or smell of the water at the mill-dam and of that at the farm. The injunction seems to me to be granted solely on the ground that the emptying of untreated manufacturing waste directly into a brook or stream is not a reasonable use of the stream. The case has been appealed to the Supreme Court of Massachusetts.

Mr. Choate. — I should say that the case that Dr. Kinnicutt has described shows the extent to which the rule I have tried to make plain might be carried. Of course there seems to be a practical injustice done there, principally because of the great inequality that exists in the value of the farmer's right or interest as compared with the right or interest of the mill owner. Now it may be that in view of the fact that our state has become so largely a manufacturing state that the continued recognition of the old common-law principle, which began in an agricultural country and was applicable strictly to the agricultural country, ought not to be extended or continued any further. And yet if one is to attempt to define and assert a principle, I think it is rather difficult to arrive at any other and do justice to everybody. The purpose of the principle seems to be to establish every man's right to have the water come to him in its natural flow, both as to quantity and quality. If you attempt to limit or cut down that rule in one respect, you will soon find yourselves in a position where you are asked to cut it down in another. To illustrate:

An upper owner might find it necessary in the conduct of

his business to actually consume a substantial amount of the flow of a river, and by that result substantially diminish the flow of the stream without interfering with its quality. The argument in your mind is this: Are not the interests of those in a given case who want to consume water of such paramount importance that they ought to be permitted to do that rather than to sacrifice them to the rights of a lower owner whose real interest is comparatively small. It is just such hard cases as that which are apt to test a principle to its utmost, and unless you adhere to it in every kind of case you will find that you have not any principle left at all.

Now I should say that the case that Dr. Kinnicutt described was probably decided on the theory that was advanced in Mr. Lincoln's case — Parker against the Woolen Company — and if that use by the Taft Shoddy Company was continued for twenty years they would then have acquired a prescriptive right to continue it indefinitely. They evidently were doing something with that stream that left it when they got through with it — after it passed through their land — in an entirely different condition from its natural condition. And if they continued to do that for twenty years they would then have acquired the right to do it. Now, if at the farmer's land below there was no appreciable difference in the water, that is, in its color, taste or quality, except to the acute perception of the cow, it seems rather hard to find the ground upon which the judge acted. Because I think the rule is that unless there has been an appreciable and noticeable difference, there has not been any invasion of a right. But suppose that we assume, for the sake of benefiting the larger interest, that we may invade that right a little, are we not at once cutting our cables and floating away from any principle at all? Until we are ready to take the other step and by some legislation say that the use of running streams for washing or for drainage for mechanical or municipal purposes is of such paramount importance that the rights of the agriculturist ought to be surrendered, hadn't we better adhere to the old principle?

A Member. — May I inquire of Mr. Choate in regard to the rights of the state to inland ponds greater than 10 acres, whether they still have rights as against mill owners?

Mr. Choate. — Well, sir, I think that is a question which is not very definitely settled in all its aspects. I think you can state possibly one principle of the law with reference to it with some certainty. I take it you have in mind a natural pond which has been partly dammed up, that is, whose area and capacity

have been increased by artificial means. Well, there are a number of difficulties that arise as to that. I think the law is quite plain that the rights of the public to boat and fish and bathe in such waters have not been affected. I think the right of the state to grant such ponds away to municipalities has not been affected at all. In the Watuppa Pond case at Fall River the court first laid down the rule that the commonwealth could grant away a great pond without paying any damages. For instance, in those cases as first decided the statutes authorizing Fall River to take the waters of the Watuppa Pond for city supply contained no provisions giving the mill owners any damages. It was only after a great deal of litigation and a great deal of very diligent work by the lawyers engaged in the case that it was discovered that the Watuppa Pond had come to the mill owners by actual grant that could be traced back to the Plymouth Colony, so that they were actually owners of that property by grant, and the ponds were never great ponds in which nobody had property rights except the commonwealth.

Another very interesting set of difficulties arises as to ponds of the character you describe, which is akin to the subject I have talked about to-night. Suppose a great pond which has been dammed up and its area increased is drawn down by the mill owners in the proper use of the water for their mills to an extent that leaves a considerable tract of margin around the border uncovered and unpleasant and possibly unhealthful. Has anybody got any rights, then? That question is very certain to be raised very soon, if not in this city, certainly in neighboring states. It has been raised in New Hampshire with reference to Winnepesaukee and Great East Pond. I know the attorney-general of Maine has been asked to begin proceedings to adjust the rights of mill owners on Salmon Falls River and Great East Pond, the head water of the river, which happens to be partly in Maine and partly in New Hampshire. Great East Pond was used for storage purposes for mills on the river as far back as 1825, and about 1841 or 1842 was dammed at the outlet and so substantially raised that a great many acres not included in the natural area of the pond were flooded. It happened within the last summer, and a number of years previously, that in dry seasons the water of the pond was drawn not only to its original natural level, but below, and in recent years all around its borders, because it is a beautiful country, people have built summer houses and they have found themselves so that between their houses and the margin of the water there was a long stretch of meadow bottom covered by old stumps which was very offen-

sive both to smell and sight, and created a very awkward and disagreeable situation. And the question immediately arose, What right had they as individuals to stop that sort of thing? The question will, I presume, be litigated before long. It must be reasonably plain, however, that if the mill owners have acquired the right there either by statute or by actual use for more than twenty years to raise the waters of a natural pond above their natural level that they are not violating anybody's legal right if they only draw them down to the natural level. Going beyond that point and lowering the waters of a great pond is a pretty questionable operation, and I should think it might involve mill owners who depend upon Lake Winnepesaukee in difficulties.

PROFESSOR PHELPS. — The state of New Jersey has given one of its commissions jurisdiction over tidal waters, so that commission may prohibit the discharge of any sewage into the ocean. I did not quite understand Mr. Choate's position in that matter, and I'd like to ask him whether that is legally within the powers of the state.

MR. CHOATE. — Please state that again.

PROFESSOR PHELPS. — Whether it is within the powers of a state to give a commission jurisdiction over the ocean front, so that it may prohibit new works and order old works taken out and purification works put in.

MR. CHOATE. — Yes, I should say there was no question that that was within the powers of the state. It is a regulation in protection of public health. A state, either for that or any other public purpose, may deprive you of any right in land. What would be involved in that case you suppose would be a private right, or a supposed private right, to drain into the sea, which might be taken just exactly as the whole estate might be taken. The principal question involved would be whether the state could do that without having to pay damages, and I'd hazard a guess that it could, because of the power invested in the state to exercise any reasonable means for the protection of its people.

MR. ARTHUR T. SAFFORD (from remarks as chairman in introducing the subject). — I wish to make the following comparison between the conditions thirty years ago and at the present time with regard to the pollution of the streams in this state. In a report * by William Ripley Nichols to the State Board of Health

* A report to the State Board of Health of Massachusetts. By Wm. Ripley Nichols and George Derby, M.D. State Board of Health, January, 1873.

of Massachusetts, January, 1873, page 91, is the following statement:

"It would thus appear that for the present the rivers of Massachusetts are not polluted to such an extent as to cause alarm, and yet neither the Blackstone River nor the Merrimac below Lowell would be recommended as a source of supply for a city. It is, however, to be borne in mind that our manufactures and, consequently, the population of our manufacturing towns, are rapidly increasing, and that in the case of the larger towns more efficient systems of water-supply and of sewerage are being rapidly introduced. The day is probably far distant, when we shall reach the state of things at present existing in the manufacturing districts of England, but, in many cases it will only be a question of time; it is hoped, however, that further examination may lead to suggestions which will tend to prevent the unnecessary abuse of running streams."

Thirty years later, in the State Board of Health Report for 1902, page 330, we find the following:

"Manufacturing wastes of various kinds are very important factors in the pollution of streams, and the present condition of one of the most grossly polluted streams in the state is due almost wholly to the discharge of manufacturing wastes into the stream and its tributaries. The manufacturing wastes which have the most serious effect in polluting streams and are most commonly met with in this state are the wastes from woolen mills, including the wastes from the scouring of wool and the washing and dyeing of cloth, wastes from tanneries, from paper mills, from shoddy mills, from print works and from rubber mills, silk factories and gas works.

"The wastes from the processes of wool-scouring usually contain very large quantities of dirt and organic matter of various kinds, and are very serious sources of pollution of streams at many places."

The change in conditions, indicated by these statements, makes the question of stream pollution a very important one; and while the details of the treatment of stream pollution will be left to the sanitary engineers, the question is essentially a legal one.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1908, for publication in a subsequent number of the JOURNAL.]

ANNUAL ADDRESS.

By Edward C. Kinney, President of the Montana Society of Engineers.

[Read before the Society at its Twenty-first Annual Meeting at Bozeman, Montana, January 11, 1908.]

Mr. President and Members of the Montana Society of Engineers: It is eminently fitting that you meet together one day in the year for the purpose of renewing acquantances, shaking the hands of old friends and comparing notes of the work you have accomplished. Your duties are located so far apart that for many of you this is the only meeting of the year and you enjoy to the full this opportunity.

You gentlemen belong to an order which, though not much more than a hundred and fifty years old, stands at the head of the progress of the world. You are leaders in the thought and action which promote civilization, as no other body of men has ever done. Much has been done by you in the past, and the possibilities yet to be accomplished in the future roll out before you far beyond the power of the imagination. Those of us who have been in this profession for a lifetime realize more and more the grandeur and nobility of the work. What a wonderful feeling of elation comes to one who has attacked some new problem in nature and has conquered it; has compelled some force of nature to become the servant of man.

Doctor Colgate has given the definition of engineering as, to devote oneself, to get at the bottom of things, to do things. Tredgold has defined it as the "art of directing the great sources of power in nature for the use and convenience of man." That is what you are doing, and can anything be nobler than to add to the happiness and comfort of men?

In this line some of you are producing copper, gold and silver from the earth with mighty machinery designed and constructed especially to fit the unusual difficulties of the work. This not only produces money wherewith to buy the necessities and comforts of life, but also the copper to construct the vast systems of transportation and transmitting power from the source of supply to the point of its necessary use. Others have been busy harnessing the mighty rivers with powerful bands and

compelling them to turn immense wheels to produce power for the use of their masters. Again there are others, who are far from being the least, who have spent their time tearing down mountains and building up valleys, moving rivers out of the way, and bridging other rivers, for the purpose of building railroads. These roads are an absolute necessity for the transportation of the immense business that your energies have developed.

There is no doubt that you engineers are the supreme motive force of modern civilization, because your work is dynamic and not static; because you have to be obedient to absolute and immutable laws; because in seeking out those laws and using them for the benefit of mankind you are freeing man, making him the master where he was formerly the slave of nature. By your inventions you are replacing the aching and strained muscles of manual labor by the tireless machine. There has been a tremendous advance in the social and business world, and while this advance has made the rich man incredibly richer, it has at the same time lifted up hundreds of thousands of men who, under the old conditions, would have known nothing but hopelessness. It has lifted out of utter degradation tens of thousands of others who are desirable citizens because of the work of you engineers.

The condition of the Montana Society of Engineers for the past year has been good. There has been a number of additions of new members and only one death, that of Mr. Charles A. Molson. The meetings of the Society have been well attended and the interest manifestly good.

The engineers generally over the state have been unusually busy until the latter part of the year, when the financial difficulties have caused some slacking down of the engineering projects.

Mining.

From the Helena District, Mr. F. L. Sizer reports as follows: The year just closing has been an unusually active one in mining throughout Montana, and certainly Lewis and Clark County and territory adjacent to Helena have had their share of prosperity. While the high price of lead and copper prevailed, producing mines were handsomely rewarded and the average price for these metals for the year 1907 will show a high level. Profit in mining, either actual or prospective, has stimulated further prospecting, has afforded employment to an unusually large number of men and has benefited all classes of tradesmen.

The scarcity of first-class miners in this vicinity (largely due

to the high wage scale prevailing in Butte) has made it difficult for the mine operator to carry out all of his plans to the best advantage. Material of all kinds has been almost as scarce as labor and hard to get promptly, thus delaying construction work. In spite of these drawbacks some notable progress has been made.

The Corbin District, 30 miles southwest of Helena, has been actively developed. Three mines have been shipping copper ore, presumably at a profit, and several deep shafts for prospecting purposes have been steadily at work.

The Rose Gold Mine near Jefferson has shown up a large amount of high milling gold quartz by recent work and will doubtless be properly equipped another season. Perhaps the most important newly-opened mine near Helena is the Spring Hill Mine in Grizzly Gulch, 3 miles south of the town. The extent of the vein of this gold-bearing quartz lode is as yet unknown, but certain it is that it is very large, — properly speaking, a mother lode,— and doubtless the source of most of the gold in Grizzly and Last Chance gulches. Since last February, when the present company became the owner of this mine, it has been actively developed, both lineally and to a greater depth, justifying the previous good opinion expressed of it and already showing ore in sight to an amount many times greater than the price paid for the mine.

Since September the quartz has been milled in the 20 stamp mill of the Whitlatch Mining Company, now under lease to the Spring Hill Mining Company and the tailings are now being treated by the cyanide process in a plant recently completed by the latter company, at Unionville, adjoining the stamp mill. The success of this enterprise has stimulated prospecting upon the course of the lode both east and west of the Spring Hill property, resulting in encouragement for further development both upon the ground of the Spring Hill Extension Company and on the Nonesuch Mine in Arastra Gulch, operated by John A. Rowand, as well as in the case of other individual operators in this immediate locality, all of whom are hoping to locate other pay shoots on the course of this great lode.

At Rimini, the Valley Forge has been a steady producer, and since the completion of their 4 000-ft. aërial tramway for delivery of ore at the railroad track, a regular output of 1 200 tons per month has been maintained. This is a silver lead ore carrying gold and has been sold to the East Helena plant of the American Smelting & Reduction Company. The increased ore bodies have

justified the management in starting to drive a new deep tunnel from the level of the railroad track which will ultimately cut out the necessity for the tramway, besides developing the mine to an additional depth of 500 ft.

In the vicinity of Marysville the Bald Butte Mine has opened new ore and has (rather unexpectedly except to those who have been keeping close track of it) resumed the payment of dividends.

The Bell Boy Mine and the General Grant Mine in Towsley Gulch have been operated and will surely make producing, paying mines. Some work has also been done on the old Blue Bird Mine, and the St. Louis Company at Marysville will shortly resume operations on this property.

In the Scratch Gravel district, 4 miles north of Helena, besides a number of prospects worked more or less intermittently, the Purnell Mine has been developed by a shaft 300 ft. deep, and since cross cutting has been done several promising veins with good values in gold and copper have been encountered.

Three miles west of Helena, just back of Fort Harrison, a very good showing has been made by the West Virginia & Montana Mining Company, and shaft sinking to a depth of 200 ft. is now in progress.

The Argo Copper Mine in Hell Gate Canyon, 28 miles northeast of Helena in Broad Water County, has been continuously operated and was shipping ore and concentrates to the Washoe Company in Butte until the recent shutdown necessitated finding another market. This mine has been developed by a winze 100 ft. deep below the tunnel level during the year and shows continuity of the size and value of the ore bodies above the main working tunnel. It is owned by the Eclipse-Argo Mining Company, and when the price of copper becomes more stable extensive improvements in equipment and further developments are contemplated.

In Avalanche Gulch, next east from Hell Gate, a similar property is now being opened by Spokane parties, and the development is said to be highly satisfactory. This copper belt is one of the most promising districts near Helena and has been a long time reaching even its present stage of imperfect development. In the Spokane Hills, south of the Missouri River and nearer to Helena, some prospecting on copper veins has been done. A number of other small operations are in progress, all of which add to the total of mine development very greatly, and with more settled conditions in business they will be actively

prosecuted and some of them will result in the opening of permanent producers.

The Butte District.

Robert A. McArthur reports as follows:

There has not been any great amount of work of engineering interest in the Butte district during the past year.

The underground development of the various mining companies of the district progressed steadily up to the time that the drop in the price of copper caused a cessation of activity.

At the High Ore Mine of the Anaconda Company the shaft reached a depth of 2 881 ft. during the past year, making it the deepest shaft in the district. It is the main pumping shaft of the Anaconda Company's mines and also of some of the adjoining mines.

At the Pennsylvania shaft of the Boston and Montana Company a new hoisting engine, boiler plant and steel head frame, together with the necessary buildings, have been installed. The hoisting engine was built by the Allis-Chalmers Company, has cylinders 32 in. by 72 in., a capacity of 3 500 ft. in depth, hoisting a total load of 34 000 lb., or a load excluding weight of rope, of 21 225 lb. The rope used is 1.5 in. round steel and the total weight of the engine is 264 tons. The boiler plant consists of 4 Sterling boilers of 300 h. p. each, with a steel smokestack 8 ft. in diameter and 175 ft. in height. The head frame is of the usual type of the district, being of steel 100 ft. in height from the shaft collar to the center of the sheave wheel, and is fitted with skip bins for the automatic dumping of the ore. Pockets for skips and cages are provided adjoining the collar of the shaft.

At the new Leonard shaft of the Boston and Montana Company the compressor plant was completed by the addition of two electrically-driven Nordberg air compressors, making three in commission. During the annual meeting a year ago the engineers visited this plant, only one compressor being in commission at that time. At the tramway shaft a new hoisting engine, a duplicate of the one at the Pennsylvania, has been installed, together with a new steel head frame.

The foregoing includes most of the work of any magnitude or engineering interest done in the district. There has been the usual amount of repairs and alterations and a great deal of work of installation and equipment at the numerous smaller development properties, but as a whole of very little interest from an engineering standpoint.

Coal Mining.

Mr. F. W. C. White reports as follows:

The only work of interest that has been done in the coal department this year has been the opening up of our properties in the Bear Creek field. Some time in May the first ground was broken for No. 1 mine, and to-day it is producing 500 tons of coal daily, with a capacity for 700 tons per day. At the same time we have been sinking a rock slope for No. 2 mine to tap the deeper veins in the field. This slope has already cut No. 1 vein at 350 ft., the intention being to continue it to No. 2 vein this winter, then to stop.

Altogether there are five, if not six, workable veins in the field, and the lands owned by the company are estimated to contain not less than 75 000 000 tons of coal, the greater part of which is tributary to the No. 2 slope now being sunk. So that No. 2 slope has a long life before it. Besides the mine work, about one mile of comparatively heavy grading for railway had to be built, besides yards for each mine. About 25 houses have been built for employees, the intention being to build about as many more next year. Ground has been leased to employees for building purposes, and at least 20 families live in their own homes, which are quite substantially built. The camp bids fair to become a model camp and is to be known by the name of "Washoe," a post-office of that name having been established. None of the permanent buildings have yet been placed for No. 2 mine, such as engine or boiler houses, the heavier construction having been stopped 3 months ago.

From Lewistown, Mr. Otto F. Wasmansdorf reports that the Central Montana Coal Company has been organized with 400 acres of very high-class coal. It is the intention to build a narrow-gage railroad to the mines to deliver the coal to Lewistown. The estimated tonnage of coal in sight is 3 000 000 tons. The road is 12 miles long and Mr. Wasmansdorf is the chief engineer.

The Chicago, Milwaukee & St. Paul Railway Company is opening up some very large coal mines near Roundup in the lower Musselshell Valley. It is already taking out a small quantity of coal.

Water Power and Electric Plants.

Mr. M. H. Gerry reports as follows on the new dam at Hauserlake.

The dam is located at Hauserlake on the Missouri River, 18

miles below the Canyon Ferry dam of the Missouri River Power Company, and 18 miles from Helena.

Work was commenced on the dam in July, 1905, and completed ready for filling the pond on January 25, 1907. Transmission of power from the generating station commenced February 15, 1907, the time consumed in filling the pond being about 15 days. Water is backed up to the toe of the Canyon Ferry dam and also up the Prickly Pear Valley to within 8 miles of Helena, thus providing a very large storage of water to cover fluctuations in the flow of the river. The maximum head on the dam is 70 ft., and normal operating head is 65 ft. A foundation of concrete, with an upstream seal of Friested steel interlocking sheet piling, was constructed to support an all-steel superstructure of the gravity type, furnished by the Wisconsin Bridge Company of Milwaukee. All construction work, except the erection of the steel, was carried out by the Power Company's engineers under the immediate direction of Mr. M. H. Gerry, Jr., manager and chief engineer. A rock-filled timber crib, surfaced with timber, serves as an apron below the spillway, which is 500 ft. wide, the total crest width being 615 ft. A short open canal at right angles to the east end of the dam conducts the water to the entrances of 5 turbine penstocks, each 12 ft. in diameter, bedded in concrete, which dip directly into the power house. The power house is 53 ft. by 212 ft., with a steel frame, rock walls and reinforced concrete floors. A fire-proof curtain wall separates the generator room from the transformer and switching room. The installation consists of 5 pairs of 48-in. S. Morgan Smith horizontal turbines directly connected to five 4 000 h. p. Westinghouse generators; three 25-in. turbines connected to 300 h. p. exciters; and nine 2 750 h. p. transformers, together with necessary switching apparatus and accessories for raising the voltage of the power generated from 2 400 volts to 70 000 volts, 3 phase, for transmission over duplicate lines, 68 miles to Butte and 90 miles to Anaconda, where the power is rapidly supplanting steam power for all purposes in connection with mining and smelting, with a large saving in cost and an increase in efficiency and output under all the various conditions when it is used.

The Butte Electric and Power Company and its Allied Companies.

The following facts have been abstracted from a long report to his company by Mr. Max Hebgen. I should be glad to give you the whole of the report but it is too long for this occasion.

The Madison River Power Company has its generating plant at the head of the lower canyon of the Madison River, about 28 miles above its mouth. At this point the company has erected a dam about 65 ft. high which creates a lake covering an area of 9 sq. miles. The development here is, first, the old Nunn Station, having a capacity of 3 000 h. p., and the No. 2 power house, with 9 000 h. p. developed and 3 000 h. p. additional that will soon be installed. There is also the No. 3 development some 5 miles farther down the river, that has been begun and will be finished in a year or two, that will add 15 000 h. p. more. This h. p. is based on the minimum flow of the river, which is taken to be 1 100 cu. ft. per second, and the stored water, that will bring the available flow up to 1 600 cu. ft. per second. In addition to the lake that has already been created on the Madison River, there is to be another reservoir built in the upper Madison basin to be known as the Hebgen Reservoir. This reservoir covers 13 450 acres and, with a dam 80 ft. high, will give a storage capacity of 13 000 000 000 cu. ft. The dam will be 80 ft. high, with a bottom width of 100 ft. and a top width of 400 ft. These plants, when extended to their full capacity, will yield 35 000 h. p. The power from these plants is transmitted under a pressure of 40 000 to 60 000 volts to Butte, Belgrade, Bozeman and Livingston.

The company's power plant on the Big Hole River is about 3 miles from Divide Station. The power development at this station is 4 000 h. p. and is delivered by mine to Butte.

Besides the dam and reservoir at the power plant, there is another dam and reservoir about 20 miles up the Big Hole River known as the Wise River Reservoir. This has a capacity of 450 000 000 cu. ft. of water. Another reservoir site is also available having a much larger capacity that will be built in the near future.

These various plants, as well as the reserve steam plant at Butte, are connected by a transmission line of 40 000 to 60 000 volts pressure and are so arranged that power from any one plant may be transferred to any other point in case of accident to any of the stations.

Railways.

Mr. William Ashton reports that the Oregon Short Line Railway has made practically no improvements on its line in Montana during the last year.

The Yellowstone Park Railroad, which is being constructed by the Oregon Short Line Railroad Company from St. Anthony

to the west entrance of the Yellowstone National Park, has been extended from Idaho into Montana over Rea's Pass, thence to the west, or Madison River, entrance of the Yellowstone National Park. About 9.8 miles of this railroad are in Montana. This line is now completed so far as track laying is concerned, and in shape for operation. We expect to do considerable Yellowstone Park business over this line. It is our intention next spring to arrange for passenger trains to leave Salt Lake in the evening and arrive at the west entrance of the Yellowstone National Park early the next morning. By this arrangement parties from Salt Lake and Ogden can make the trip to the Park, or returning from the Park, during the night. In constructing our line over Rea's Pass we used a 2 per cent. maximum gradient on the south side, 1 per cent. maximum on the north side. You will therefore note that in addition to the alignment over this pass being much more favorable than *via* Monida, the grades are considerably lighter.

For the Northern Pacific Railway, Mr. F. J. Taylor reports that they are building a new line along the Missoula River from St. Regis to Paradise, 22 miles in length, connecting the Cœur d'Alene branch with the main line.

Work is in progress on 25 miles of second main track over the Bridger Range between Livingston and Bozeman, and on 75 miles of second main track between Garrison and Missoula.

Besides the above, the principal work done has been on improvements and betterments of the main line, and considerable work has been done in enlarging engine facilities at division terminals and increasing shop facilities.

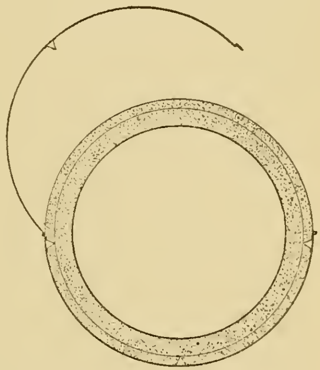
The Chicago, Milwaukee & St. Paul Railway has gone steadily on with its work till it is nearly through with construction. The track is laid from Harlowton east to a point on the divide between the Musselshell River and the Yellowstone River, about 140 miles east of Harlowton. Track is still being laid and will soon be completed to connect with the track from the east. The grading for the new track in Sixteen Mile Canyon is fully 80 per cent. completed. The piers for the Missouri River bridge at Lombard are completed and the bridge is on the way out from the factory. From Lombard to Butte the track is in a large part completed and the heavy work is well on its way. The line from Butte west is well under way, but I have not the data for much of a report on it.

The irrigation situation has been very quiet except for the work of the United States Reclamation Service. I have the

promise of a report on that from Mr. H. N. Savage which I will give to you in a separate report if it arrives as promised.

In making studies for a city water-works system I have been led to examine the merits of reinforced concrete pipe and will give you some of my conclusions. For the convenience of comparison and study I have assumed a pipe 12 in. inside diameter, 8 ft. long, with a working head of 150 ft., or 66 lb. static pressure. Any other size of pipe or pressure may be used on the same general principles.

A suggested method of making the pipe is as follows: The center form is of the usual collapsible style and 8 ft. long as being a convenient length. This is set on end in a pit 2 ft. deep prepared for it, with a cast-iron base placed in the bottom of the pit to receive the ends of the forms and to keep them concentric. The outside form is made in sections only 2 ft. long, so as to give easy access in ramming the concrete solid for the pipe. The sections are divided in the center lengthways with hinges on one side and clasps on the other, so that it may be opened. On the inside of the outer shell will be fastened four V-shaped pieces made of thin sheet steel, put in lengthways, three of them in what may be called the lower half when it is laid on its side, and one in the center of the upper half. These V-shaped pieces are notched at intervals of 1.5 in. and opposite each other so that the reinforcing rings may be spaced as required for strength. The rings will be set in the lower half at approved distances, and when the top half is shut down and fastened the reinforcing bands will be held solidly in place and 0.5 in. from the inner side of the form. This will give 0.5 in. of concrete outside of the reinforcing bands and so protect them from rusting. Wires for reinforcing the pipe longitudinally are introduced through the inside of the rings and wound around the ring nearest the end and spaced at equal distances. To start the construction of a pipe the inner shell is set vertically in the pit. The first section of the outer shell is placed over it at the bottom with the longitudinal wires projecting up and bent out a little over the edge of the section. The concrete is introduced and rammed solid. This ramming



Sectional View of Pipe and Form.

is the absolutely essential thing in making pipe, as on that depends the watertightness of the pipe. When the first section is complete the projecting wires are gathered to the center at the top of the inner shell and a small ring slipped over them. The second outer shell is placed and the longitudinal wires bent outward and the concrete introduced as before. When the last outer section is in place the longitudinal wires are cut to the proper length and twisted around the last ring at the end, and when it has been properly filled with concrete the whole pipe has been reinforced each way, all metal is completely covered in and there is no chance for rust. When two of the outer sections have been set, a movable circular platform, divided in the center and hinged, is drawn up and placed around the pipe, from which the balance of the work is done. When completed a light derrick lifts the form and sets it in the stock pile. When the pipe is ripe and the outer shell removed, the grooves left by the removal of the small forms that hold the rings in place should be filled and packed with a rich concrete and smoothed by a hand trowel.

The collars for the couplings of the pipes will be made similar to the pipe but larger and about 8 in. long. The joint packing will be of concrete, and driven hard with a hammer and calking iron.

As to the strength of concrete for making joints, I will say that last year I had occasion to build an inverted siphon over a new river channel on the Chicago, Milwaukee & St. Paul Railway work. Twenty-four inch heavy cast-iron water pipe was used with four 45-degree elbows to turn the pipe from the land level down to the bed of the river and back up again. The joints were all packed with concrete and held the water perfectly. Later a great flood came in the river and washed out the filling under one of the pipes and an elbow at one end. The 12-ft. length of pipe weighed 2 500 lb. and the 4-ft. elbow weighed 1 000 lb. The concrete in those two joints held that weight of 3 500 lb. for some months till it was convenient to fix it up. I should not hesitate to use concrete for joints in place of lead in even cast-iron water pipe.

The bands for reinforcing the pipe should be of mild steel of not less than 60 000 lb. tensile strength, and calculated for use at not more than 15 000 lb. per sq. in. The rods should be cut to the exact length, bent to the proper form and butt-welded with an electric welder. This will give a uniform size to the reinforcing hoops. Taking the assumed pressure of 66 lb. per sq. in., the

bursting pressure on 1 ft. of length would be 9 504 lb. As half of pressure applies to each side of the hoop, the pressure on one side would be 4 752 lb., and taking 1 in. of steel as 15 000 lb., it would require 0.32 sq. in. of steel to hold it with a factor of safety of 4, this on the supposition that the steel holds the entire bursting pressure. Dividing this amount of steel into 4 bands or placing them 3 in. apart from centers and making them 1 in. wide, the bands would be 0.08 in. thick.

The best authorities that I have give the tensile strength of concrete at from 200 to 600 lb. at thirty days set. Assume that we make a concrete of the strength of 400 lb. at thirty days. Then assume a shell of 1 in. thick inside of the bands, which is about as thin as I should want to go for strength and handling. Again our authorities say that the shearing strength of concrete is from 1.1 to 1.3 times the tensile strength. Suppose we take as our shear 1.2 times 400 lb., we have 480 lb. per sq. in. for the shearing strength. As our 1-in. bands are spaced 3 in. on centers, we have 2 in. between bands for the concrete to hold the strain. We are using 66 lb. per sq. in. pressure, and on the 2 in. there would be 132 lb. Now as the thickness of the pipe is so great compared with length of the section, and the compressive strength is so far in excess of its tensile strength, the concrete could not break by bending out, and the only way it could break would be by shearing between the bands. Again, if it should shear at all it would have to shear twice, that is, at each side next to the bands. We have then 2 in. of shear or 960 lb. of strength to hold the pressure on 2 sq. in., or 132 lb., or a factor of safety of 7. This does not take into account the 0.5 in. of concrete that I have placed on the outside for protection of the steel, which, though not as reliable as that inside the hoops, would still have a good deal of strength. Again, when the segment began to rupture by shearing, it would have to break across at least in one place and would give the added strength of the tensile strain, which we have taken at 400 lb. per sq. in. and on the 2 in. there would be 800 lb. of strength added. Altogether we should have nearly 1 000 lb. of strength to hold 132 lb. of strain on the concrete.

I have made these computations hurriedly and you had better check them carefully before using them.

In putting in a city system I should use cast-iron tees and crosses with all hub ends. For service cocks I should build as many into the pipes as there was any prospect of needing and locate them properly while laying the pipe. Afterwards if

others were needed I would use a cast-iron sleeve built in two parts to be placed around the pipe and edge-bolted, then pack with concrete and tap as you would cast-iron pipe. This system is unusually elastic, as you may make pipe of any size or strength. The place of manufacture should be at the most central point to the work, having regard to the convenience of assembling the material. Without searching for final prices, I figure that this pipe would cost about the same as the banded wooden pipe of the same strength, and not much more than half as much as standard cast-iron pipe would cost.

If the occasion for building a city water supply should materialize I should certainly recommend and urge the using of reinforced concrete for the pipes.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1908, for publication in a subsequent number of the Journal.]

THE SAN FRANCISCO EARTHQUAKE OF APRIL 18, 1906.

By Joseph H. Harper, Member of the Montana Society of Engineers.

[Read before the Society at its Twenty-first Annual Meeting, at Bozeman, Montana, January 11, 1908.]

Some six weeks after the San Francisco earthquake of April 18, 1906, I prepared an article, describing the impressions produced upon my own mind while the movements were in progress, together with a few interesting exaggerations as related by others who had a somewhat similar experience. The recounting and study of these personal impressions has always had a peculiar fascination for me, and reference to the article referred to will show how I was able to account for my own deception in a manner satisfactory to myself, but I often find it quite impossible to understand how the actual movements, as we now understand them, could have produced the fantastic impressions that have been left upon the minds of many.

A very large majority of those present have no clear conception with regard to the movements, and recall the incident as a confused succession of vibrations, jars and jolts that endured for a considerable period, while of those who did receive and can recall their impressions with regard to the amplitude or interval of the larger movements, I have yet to find two individuals, who were apparently similarly situated, who will tell the same story. Not only the physical environment, but the mental attitude of the individual, with the dim light or the absolute darkness in which many were enveloped, have doubtless all combined to deceive the senses and confuse the mind with regard to what was actually taking place. Every recital of these personal impressions but demonstrates anew the utter untrustworthiness of the unaided senses in estimating the amplitude of the movements involved.

One very naturally anticipates that a study of the movements of inanimate objects would throw some light upon the amplitude of the shocks delivered, and one with a larger experience might be able to obtain something of value on this point from the record of cracks and displacements that exist on every hand, but I must confess that my own efforts along this line have been somewhat disappointing.

I have spent many days in studying the effects of the earthquake and the fire upon the city of San Francisco, and in studying the effects of the earthquake at San José, Palo Alto and other towns about the bay, and in the cemeteries and country adjacent, and have made repeated visits to each of the places named, without being able to reach any definite conclusion regarding the amplitude of the larger movement, that which is described by many people as a rocking motion, and which is that portion of the quake that inflicted by far the greater part of the damage sustained.

I am forced to conclude that when the earth shocks become so severe as to cause vibrations far beyond the range of our ordinary experience, our senses fail in comprehension, and I feel that no accurate knowledge of the actual maximum can be obtained except from the record of instruments constructed for the purpose, and further that a seismographic record will not be a reliable index of the actual movements except for a very restricted area about the locality in which it is placed. As reliable instruments of this character are somewhat expensive and when maintained in perpetual order require considerable technical attention, and the number established in any particular locality is naturally limited, we should not be surprised to learn that but few were found within the area seriously affected, and none, I am told, were situated in San Francisco.

Without doubt much can be learned by comparing the data available from other stations and when the commission which is now investigating this entire subject has made its report, I think we may learn something regarding the maximum movements within the area of greatest disturbance.

These remarks, so disparaging to all personal estimates, and the doubts I have expressed about my ability to place a definite value upon the movements, apply only to the amplitude of the heavier shocks and do not apply to their frequency, nor do they apply to either the amplitude or the frequency of the lighter vibrations that endured for a much longer period and constituted a large part of the disturbance. These lighter movements could be fairly understood by those who were awake at the time, their amplitude estimated with some degree of assurance, and the frequency of all could be counted, quite closely I should think, by those who are accustomed to rating mechanical movements.

Before going further I will relate more carefully than I have heretofore done my experience during the quake and give the results of my personal observations during that time, eliminating

therefrom, as far as possible, those features in which I can now recognize that my senses were much confused, and that through them I was greatly deceived.

Within an hour or two after the occurrence I was asked for an estimate of its duration. I was about to reply one minute, when that time seemed rather long and my answer was 50 seconds. At the time many were estimating it at 5 and some even at as much as 10 minutes. I now think that I missed something in the earlier stages, and that from the first to the tenth second was really a longer interval than I then thought it. There is a chance for some discrepancy in determining the end of the movement, as the vibrations died out very gradually and may have continued longer than a person whose attention was seriously engaged would notice them. There were a number of lighter shocks during the day, but after the one of the early morning they attracted but little attention, and these continued, separated by irregular and increasing intervals that extended from minutes to hours and days, for many weeks before they finally ceased.

Assuming, then, 50 seconds to be a correct measure of its duration from the first warning note to the last perceptible vibration, and using this as a basis, I will subdivide the period, designating the interval by the numbers of the second elapsing as counted from the first warning note.

The prelude, or opening, was a very low rumbling noise like distant thunder, or an ore car far away in a mining drift, which began at the first second and gradually increased and became more distinct until about the fifth, the sound gradually growing in volume much as it does when a train approaches one through a tunnel. During this five-second interval there was no movement that attracted my attention, and I attributed the sound to some machine in the basement running at an unusual speed.

At the fifth second a vicious intermittent jolting movement began, and in mp estimation continued without cessation at any time to the fiftieth second or the end of the quake. This motion appeared to be mainly in a vertical direction, with an amplitude ranging from $\frac{1}{8}$ in. to $\frac{3}{8}$ in., and moved with a frequency of about 240 per minute, or about 4 cycles per second. These vibrations seemed to rise in pulsations and die down, to be renewed with greater violence at intervals ranging from 2 to 4 seconds each, this change apparently being accomplished by a variation in their altitude rather than by any change in their frequency. These movements were forceful enough to make

everything loose dance and chatter continuously, they were accompanied by a considerable volume of sound, though they did not rock the building very severely, and finally died away in falling pulsations by a reversal of the manner in which they had arisen. I believe this movement to have been continuous in some degree for the entire 45 seconds, for the reason that, between the intervals of the more violent oscillating movements, which I will soon describe, the rattling of the chandelier fixtures, the windows and the chattering of some loose objects on the marble-top dresser due to this movement, could be distinctly heard, just as both before and after the heavier shocks.

At about the tenth second there came a crash as of something shattered, and the falling of the broken parts.

I shall probably never know what caused the crash; my first thought was that the elevator had been run into the sheaves, but a moment later, realizing that an earthquake was upon us, I raised myself to a sitting posture, and was certainly wide-awake from this time on, though I made no further move till all had passed and everything was again quiet.

I have some misgivings with regard to the preceding time intervals as I have given them, but from this moment on I can speak with more assurance.

The vertical vibratory movements I have just described were at this time in full swing and increasing in amplitude and violence at almost every rising pulsation. These shocks, though more violent, did not differ greatly from some I had before experienced, and had this been all might have endured for a full minute and passed without doing any great amount of damage. But this was not all.

From the twentieth to the twenty-sixth second, for an interval of about 6 seconds, there appeared a violent reciprocating movement of tremendous energy, much stronger in its horizontal than in its vertical component, having an interval of about 90 per minute or 1.5 cycles per second, which was superimposed upon the lighter vibrations and while in progress wholly dominated all other movements. An exhibit that aptly illustrates my idea of the manner in which these different vibrations are imposed upon one another may be seen by observing the ripples that always play over the surface of the larger waves when the water is rough.

These heavier shocks were not of constant energy but seemed to progress in three distinct pulsations, each separated by an interval of comparative quiet, the change, as was noted with

regard to the lighter vibrations, being effected by a variation in amplitude rather than in the frequency of the movements. For the first three or four shocks the motion appeared to be in a general easterly and westerly direction; then, after a pause of a moment or so, two or three somewhat lighter occurred with an apparent motion nearly north and south; when, after another pause of a second or two, and another change in direction, some three or four additional shocks, the first of which seemed more violent than any of the preceding, were delivered in an easterly and westerly direction; when these in turn died away and disappeared among the lighter movements that I think had been in progress all the time, and that continued to the end of the disturbance.

Words fail utterly when I attempt to convey an adequate idea of the dynamic energy manifested in each of these larger movements, as they appeared vicious in the extreme, and forceful to a degree far beyond anything I had ever experienced or imagined as possible. The blows were delivered as intense, instantaneous and resistless shocks, of startling severity and limitless power, crushing everything that offered sufficient resistance, and rending and tearing everything that did not bend to their requirements. The building rocked and swayed in an alarming way, while at every lurch there came the sound of groaning timber, the creaking of nails and spikes being drawn, the snapping of painted woodwork, all of which, when joined by the rattle and jar of everything loose, filled the room with a confused din that was disconcerting in the highest degree.

For reasons heretofore given, I cannot estimate the amplitude of these larger movements with any degree of assurance, but I cannot see how the effects produced by them in my immediate neighborhood could be accomplished without an actual movement of at least 2 inches, and indeed for some of the exhibits it would seem that considerably more than this would be required.

You will understand that what I have written has special reference to what occurred in our own apartments, that is, on the fifth floor of a very well-constructed frame building standing on a good brick foundation at 808 Bush Street, but I imagine it will fairly describe the experience of a large majority of those who were similarly situated about the city of San Francisco.

In estimating the magnitude and intensity of the movements in any locality, one must depend largely upon the character of the effects they produced, and these when found are generally

more or less illusive, and very unfortunately are often quite contradictory.

The lighter shocks, those whose main component was vertical, I imagine were substantially the same in all parts of the city and were but slightly modified at elevations above the ground, while with the larger or horizontal movement a marked difference seems apparent between different points in the same locality, and I feel quite certain they were often greatly magnified, or much modified, dependent upon the character of the structure in which the observer was situated and his elevation above the ground. Generally they appeared to be amplified in some degree on the upper floors of most buildings, but it does not follow that the higher the floor the larger they became, for if the building were tall enough, one or more nodes would usually appear in the vibrations, which must greatly modify the character of the movements.

The point where the reversal took place was made manifest by the shattering of a story or two, while at other points the walls would escape comparative injury. There were so many buildings to be seen about the city with one story, usually between the fourth and eighth, badly damaged, while those above and below were apparently unharmed, that this feature became quite noticeable. It is generally believed that the shocks were much more severe on what is known as made ground, or land that has been reclaimed by filling in along the water front, than they were in sections where a rock foundation was obtainable. It is true many buildings on an elastic foundation suffered severely, but it is also quite true that many frail structures so situated were marvelously preserved. My impression is that the most intense shocks were delivered from the firmest foundations and to the buildings most rigidly constructed, and while the amplitude of the movement may have been greater where a more elastic foundation or method of construction prevailed, I think the shocks lacked something of the dynamic energy that is evinced where the foundations were more solid or the structure less elastic.

Volumes might be written descriptive of the havoc wrought by this terrible visitation which in a few moments wrecked the city and started the fires which eventually destroyed it, shattered the nerves of a large majority of its population and profoundly impressed all by a momentary exhibition of limitless power, but I have time only to note a few cases which occur to me as most interesting.

One is early impressed by the abundant evidence of the most erratic damages, and still more unaccountable immunities, that are exhibited side by side on every hand. In our own apartments (on the fifth and upper floor) the motion was certainly severe, as a steam radiator that naturally stood 2.5 inches from the wall was thrown over until it inclined at an angle of 25 degrees from a perpendicular, though the iron fittings by which it was connected were so ridged that I found it impossible to replace it unassisted, and yet in these rooms nothing of moment was broken and no other furnishing was seriously disturbed, while in the rooms next below nearly everything movable was overturned, many objects were broken and much damage done. Mrs. Harper explained this by saying that in our rooms almost everything stood out from the side walls while in the rooms below many of the furnishings were set close against them, and in this remark I have found an explanation for much apparently fitful and capricious destruction noticed in all parts of the city. In the simple conditions here presented, with the results observed, will be found a key that will explain the collapse of the City Hall, the destruction of much property in San Francisco and the fall of many buildings at Palo Alto, Agnews, San José and other points about the bay.

The lesson to be drawn, and to which I shall again refer, when briefly stated, is that objects must be separated by an interval so great that they will not collide, or they must be bound together so they will move as one. Marble-topped furniture, tables in particular, seemed to be marked for destruction, and they were, literally by the hundred, fired from the walls across the apartment and were very frequently disfigured or broken. The fire mantels and marble wainscoting were interior decoration for the destruction of which the shocks appeared to have a peculiar *penchant*, and when we recall the manner in which these fittings are usually fastened, it is easy to understand how the first movement might separate them from the wall and the second send them shattered and broken far into the room. In like manner a plastered surface, if at all loose, would be easily broken and thrown into the room, but I think firm walls of good mortar usually came through without serious damage. Though I have noticed many marvelous escapes, bric-à-brac was usually scattered in wild confusion, small flat objects were often completely overturned, pictures were thrown down, while the spectacle of one, though two or more feet across, with its face turned to the wall, was not an unusual occurrence.

I have found the cemeteries a fruitful field for the study of eccentric movements. In Laurel Hill I noted two similar granite shafts, separated by less than 200 feet, one of which had been turned to the right upon its base some 15 to 20 degrees, while the other, upon the same style of a foundation, had been turned as far to the left.

Among many of like character I noted a monument, with pedestal, shaft and capital, in which the shaft had turned in one direction upon the pedestal, while the capital had turned in the opposite direction upon the shaft on which it rested to a much greater extent, and both movements were attended with an adverse lateral motion of the members.

There is no apparent regularity in the direction in which the upper stones have moved upon the lower. A northwesterly and southeasterly direction may be most frequent, but I have noted these movements toward every point of the compass. There was nothing in the movement that gave me an impression that it was rotating, but a number of witnesses have stated that among the other movements they detected a circular or twisting tendency. I think the tendency to rotate is the resultant of two or more components from the other movements, and the manner in which they were combined in any particular locality probably determined the direction in which the object affected would turn. There remains, however, a difficulty in understanding how a capital can turn in one direction while the shaft upon which it rests is turning in the opposite direction upon its foundation.

The most perfect illustration of this tendency to rotate which I have anywhere noted was seen in a brick chimney about 2 feet in height, and the only one that I could see standing in that locality, which had made a quarter turn to the right by the movement of each individual brick upon the one on which it rested, with their final arrangement almost as perfect as could have been secured had a mechanic been employed to place them there.

Though I believe a measurement of the horizontal component of the earth's movement would greatly exceed any instrumental record that I have ever heard mentioned, there are many tall, slender and apparently unstable objects about the city that still stand erect and uninjured.

In spite of their amplitude and complexity it is still possible that a person standing upon one foot in the middle of a room would have felt the movements less than one who had a larger surface in contact with the floor, as in the end, without question,

the sum of them all practically balanced one another, and the ultimate motion, if there were any, was probably small and the new position gradually attained.

I note three familiar objects that illustrate this feature, one being the Dewey monument in Union Square; the second, the Native Sons monument at the entrance of Mason and Turk into Market Street; and the third, two columns which many will remember at the southwest corner of the City Hall, at the intersection of Grove and Larkin streets, which stood for many months capped across by a section of the architrave which originally rested upon them. The two objects last named both illustrate the universal character of the movement, as the projecting cove at the base of the Native Sons shaft had been spalled and broken off quite impartially in all directions, while the ornamental castings at the base of the City Hall columns had been broken on all sides.

Further curious and interesting effects of the fire and earthquake might be described, as they are in evidence on every hand, but features of more practical value to the engineer and structural artisan relate to the character of material and methods of construction that can best withstand a constant war with the elements and an occasional assault of earthquake, fire or flood.

It is now apparent that, from the moment of the shock, which occurred at 5.15 A.M., the destruction by fire of a large portion of the business section of the city was foreordained, for before leaving my room at about six o'clock I had noted four separate and distinct fires, and there were really six, I have since been told, all of which looked threatening in the extreme and were apparently at that time beyond control.

I am not equipped to discuss in a technical manner the stresses and strains involved, or the size and proportion of members required to secure stability in large municipal structures of recent years, as my practice has usually lain along other lines of work, but my experience in San Francisco, and my observations since, have developed a few persistent notions of what it is desirable to attain, and some regarding the conditions it is necessary to avoid in buildings designed to stand the shocks of an earthquake and endure the fires that may follow.

There are two properties in available building material, rigidity and elasticity, that we may invoke, and these may be employed to produce two very dissimilar structures, either of which will sustain shocks without injury, but the ideal building will result from a judicious combination of the two rather than

from the exclusive use of either. A granite block and a rubber globe will both endure the roughest usage without injury, but the first accomplishes the result almost wholly by transmission, while the latter largely absorbs the force of the blow.

To build strong enough is a solution of our difficulties in but one direction, for not only should the structure stand, but it should possess a property that will absorb the energy, modify the movements and thus in some measure protect the occupant and the interior furnishing. In small buildings elasticity is of comparatively slight importance, and in all timber work is naturally attained without special effort, but in larger structures, and particularly in all tall buildings where this property seems most desirable, the best results cannot be secured unless careful provision therefor be made in the design. A large part of the immunity from damage observed in wooden buildings is doubtless due to their inherent elasticity, and to the fact that many of them were placed upon a frame underpinning from 2 to 4 ft. in height, usually lightly inclosed and often left entirely open. This style of foundation is much in vogue in California, and in San José, where the quake was probably stronger than in San Francisco, and where I saw many such buildings, I cannot recall one that had sound walls and was well built that sustained any serious damage unless the foundation had failed, and in that case they were without exception very badly wrecked.

For tall buildings the modern steel frame is the only style of structure to be considered, and in the San Francisco test they gave a very excellent account of themselves.

As usually designed the attachment between the posts and girders appears weak, and the bracing between all vertical and horizontal members entirely insufficient to safely withstand the burden of a shock, but I have a suspicion that the large riveted corner plates and the rigid diagonal bracing now being used on some of the buildings under construction is a departure on the opposite extreme.

Much is claimed for "reinforced concrete," and if concrete be properly reinforced it is without question a most excellent material, combining in a marked degree the desirable properties of strength and elasticity, but I cannot avoid an impression that this material is just now being badly overworked. Concrete in dams, bridges, retaining walls, foundations and all sub-work fills an important field, and in recent years its intelligent reinforcement has enabled us to economize greatly in quantity and to use it for many purposes for which it is not otherwise suitable,

but I do not feel that any method of reinforcement that I have yet seen will render it a desirable material for the construction of supporting members in buildings that are more than four, certainly not more than six, stories in height.

Concrete construction is usually monolithic in character, and in this respect is admirably adapted to withstand earth shocks, but one naturally speculates on what might occur if an important vertical, say one of the lower columns, should cleave on a plane approaching a diagonal through the member. With a rupture of this character we could hardly expect the reinforcement to carry the entire shear strain, and a very serious situation is presented.

A column of brick similarly situated would possess the virtue of falling slowly; it would disintegrate on a series of vertical and horizontal planes, and will usually carry its burden for a considerable time though badly shattered.

The argument that concrete is cheaper and can be placed in position with ordinary labor has largely disappeared when it is used in forming the important members of a large building, for in addition to generous reinforcement, the best of selected material must be used and a care in every detail of construction realized that cannot be attained without employment of men with large experience and special training in such work.

But poor material cannot be held responsible for anywhere near all of the failures that occurred in and about San Francisco, for poor workmanship was responsible for many, and a radical defect in the design directly responsible for some of the most lamentable. A heavy dome upon a light skeleton of steel, projecting far above the body of a building, unless securely bound thereto by a substantial and elaborate system of bracing, is a form of architecture that simply courts disaster. The imposing City Hall in San Francisco and the barely completed gymnasium at Stanford were both examples of this character, and both were seemingly wrecked much in the same manner, by battering themselves down through unequal vibrations between the buildings and their respective towers. The assertion is frequently made that the material used in the City Hall and the buildings at Stanford was very poor, a remark that caused me to examine the work with more than usual care. The material is well above the average in grade; most of the mortar used was of good quality, some in fact very excellent; and I found none worth noting at either point that was positively poor.

One would naturally anticipate that in a region where earth-

shocks were not infrequent special care would be taken to bond all work securely, but here a different policy seemed to have prevailed, for I have never seen as much poorly bonded work, nor such a quantity of work without even a pretense of bonding, as was exposed in San José and Palo Alto, and in general about the city and bay of San Francisco.

A style of construction much in vogue with the architects here, and used extensively upon many large buildings, consisted of a veneer or facing of dressed stone backed by a wall of brick, concrete or rubble work, but instead of being thoroughly bound together, the two courses were often continued for a story or more without the use of a single tie that I was able to discover, while what in mason work is termed a "header" was apparently unknown.

Much damage resulted from overturned chimneys, the falling of cornice and other ornamental members and the throwing of firewalls upon adjoining property, but danger from this source will be very greatly reduced on the buildings now going up, for as reconstruction proceeds one can note many provisions for supporting and anchoring these ornamental projections that were formerly regarded as unnecessary,

After many large fires, engineers and architects have often found it difficult to determine what proportion of the damage done to stonework should be attributed to the fire and how much to the water that was used, but in San Francisco abundant opportunity has been offered to study the effects of fire without water upon structural material, and in my judgment the use of water can add but little to the destructive effects of a great conflagration.

As in Baltimore, Chicago and other severe fire tests, so in San Francisco, the common, ordinary brick of good quality, I think, comes through with a far better record than was made by any other material in general use. The opportunities for observing it after a fire test were not as numerous as one would expect, owing to the abnormal proportion of wood that entered into the construction of the city, and owing again to the indifferent character of both brick and mortar so frequently used, which failed to support the walls after the floors and tie beams had been burned away. There were, however, a few large and well-built brick buildings in the city, and so far as my observation goes, every wall of good common brick well laid in cement mortar stood through both the earthquake and the fire without serious damage. The walls of St. Francis Church, at the intersection of

Montgomery Avenue and Vallejo Street, stand to-day without a serious crack and with the brick work but slightly damaged, while their sandstone foundations have spalled to an average depth of about 5 inches.

St. Mary's Church, at the corner of California and Dupont streets, stands with the main walls uninjured, though the rear gable that presented a large unsupported surface has fallen. The Jewish synagogue on Sutter between Powell and Stockton streets was reconstructed before I had an opportunity to examine critically, but I have been informed was well preserved. True, these walls are all heavier than it is practical to use in ordinary buildings, and this feature may have contributed in some degree to their preservation, but I think the secret lies rather in the quality of the mortar used and the character of the bond employed to bind the brick into a homogeneous whole that will vibrate *en masse* without rupture. The Appraisers' Building, corner of Washington and Sansom streets, and a number of smaller buildings that I cannot now locate, are examples of lighter walls that came through the quake in fine form but escaped without a serious fire test.

A wall of good brick well laid in good cement mortar will, I think, be quite as, if not more, elastic than one of concrete, while it will head the list for endurance under fire. The fire-resisting properties of concrete are also excellent, though it does not come through wholly without damage. If the test be severe enough, the life seems to be burned from the outer surface, and this portion will disintegrate easily, to a depth depending upon the fierceness of the fire and the duration of the test.

I regard brick as the best all-around structural material we yet possess, while concrete follows as a close second, in both elastic and fire-resisting properties.

Stone of every character failed, marble most signally perhaps, but granite, lime and sandstone all spalled off badly under the heat, and several buildings, otherwise uninjured, were so badly defaced that their practical reconstruction is a necessity.

Damage from this cause alone was really very great, as it was almost universal, and at some points the chipping was very deep, one instance noted being the north end of the Shreves Building, corner of Post and Grant streets, where the alley was literally covered with spalls, and some pieces having a superficial area of 10 or 12 inches were thrown a distance of 60 feet from the face of the building.

A variety of terra cotta finishings, and nearly all of the

unglazed tile in use, passed the fire test in good form, but all hollow work of this character suffered severely from the shock, and though an utter failure was rare, partial failures were very numerous and its general performance tends to discourage its further use in all positions where much weight is to be carried and in all localities where earth-shocks are to be apprehended. A large assortment of fancy and pressed bricks were in use, nearly all of which made an excellent record, but the glazed or vitrified varieties were often spalled and chipped at the corners and along the edges from the effects of the shock.

To build stronger than your neighbor is a safe proposition unless he is entertaining the same idea, but the spirit is too selfish to be taken seriously. The necessity, however, of paying some attention to what is being done on adjoining property was abundantly manifest at San José and other towns as well as in the city, for the crushing of a low or weak front, or the forcing of it into the street, by the pressure of taller or stronger structures on each side, was a manner of failure very frequently observed, while on the other hand, if the lower building was substantial enough to hold its own, the taller structure would be badly damaged in that portion projecting above the general level.

The conditions above named, with the inherent elements of weakness in conspicuous evidence, are so frequently encountered in all business districts that I would like to suggest some easy way of avoiding trouble, but the only efficient method that occurs to me is to leave a small open space between the buildings, and this plan, I presume, will generally be rejected. A small space, an inch or less, would generally be sufficient, and there are many ways in which it could be covered and made to appear respectable.

Much damage was accomplished by the thrust of rafters and truss members that threw the top of side walls out and caused them to fall. It seems hardly necessary to suggest that an effectual remedy for this consists in strengthening the chords and securing them at the foot of the trusses in a manner that they may sustain any thrust that may come upon them, thus making the truss a substantial tie and an element of strength instead of weakness.

The ideas suggested by the observations I have made, the more interesting of which I have endeavored to describe, may be summarized in the following half-dozen hints, which, if duly regarded in the work of rebuilding, will materially reduce the damage sustained should earth-shocks of like nature again occur.

First: Seek a solid foundation and thus insure against the

vibrations of the ground being amplified in the structure should its movements be any synchronous multiple of those made by the earth.

Second: Use the best material of its kind obtainable, and insist that it be assembled in a substantial and workmanlike manner.

Third: The walls and all members should be homogeneous if practical, and when this is not possible and different materials, as steel, stone, brick or concrete must be joined, see that they are bound together and will move as one.

Fourth: Every structure should be treated as a unit, and all members and every part thereof should be tied to insure its movement in unison; there must be no separation, none whatever.

Fifth: Avoid projections as far as possible, but when necessary, as in cornice and ornaments, furnish ample support and tie securely to the main building; avoid members that project above the general level, but when unavoidable, as chimneys and firewalls, brace firmly to the body of the work.

Sixth: Limit the height of buildings to what in other localities would be regarded as a modest elevation for one of its class, leave an open space between buildings on adjoining property and in general remember that between buildings, or between the different members of a building, or between the fittings within the buildings, or between different objects anywhere, collisions must be avoided, for in the impact of collision the work of destruction has both a beginning and an end.

[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street,. Boston, by April 15, 1908, for publication in a subsequent number of the JOURNAL.]

RECLAMATION PROJECTS IN MONTANA.

By H. N. Savage.

[Read before the Montana Society of Engineers at its Twenty-first Annual Meeting, at Bozeman, Montana, January 11, 1908.]

Huntley Project.

The lands under the Huntley Project are situated in the Yellowstone Valley and extend in a compact body from Huntley to Bull Mountain Station on the Northern Pacific Railway. The lands, which comprise an irrigable area of about 33 000 acres, are all on the south side of the Yellowstone River and are crossed by the Northern Pacific Railway and the Chicago, Burlington & Quincy Railway. The irrigable lands slope gently toward the Yellowstone River. They are in general smooth, and there will be but little expense in putting them under irrigation. The Farm Unit consists of 40 acres of irrigable land, with which is included such pasture land or woodland as could be found adjacent. The farms will, therefore, contain 40 to 160 acres of land, of which 40 or more acres will be classed as irrigable.

The Main Canal, which has a total length of 23.5 miles, is taken out at the bottom level of the Yellowstone River about 2.5 miles west of Huntley. The canal diverts at normal capacity about 400 second-feet of water from the Yellowstone River. The Main Canal for a distance of 2.2 miles is located along the Huntley Bluffs. The headworks consist of a reinforced concrete structure provided with two steel gates 5 ft. by 7 ft., and arranged to divert water without the necessity for a weir. From the headworks the water is carried through Tunnel No. 1, which is 700 ft. long, and thence through a rock cut to Tunnel No. 2, which is 1 500 ft. long. From Tunnel No. 2 the water flows through an open slough and into Tunnel No. 3, about 400 ft. long. The three tunnels have a total length of 2 650 ft., are 9.2 ft. wide and 9 ft. high at the center of the arch. They are lined with concrete, and at the entrance of Tunnel No. 3 there is a heavy reinforced concrete wasteway, which at low water will discharge under the tracks of the Northern Pacific Railway into the Yellowstone River. All structures such as culverts, siphons, etc., are of a permanent type. The building of these structures, which was completed June 1, 1907, included the placing of 3 500 cu. yd. of

concrete, the greater percentage of this being of the reinforced type.

In making the location of the Main Canal, two drops were necessary, the first about a mile east of Ballantine and the second about 4 miles farther. At the first drop a pumping plant has been installed to pump water to the Ballantine bench and the lands along Fly Creek. The Main Canal at this point will carry about 240 cu. ft. of water per second, which will be dropped about 34 ft. and will develop power sufficient to raise about 56 cu. ft. of water per second to a point 45.5 ft. above the Main Canal where it will be discharged into the High Line Canal. The machinery for this plant reached Ballantine early in July and is now installed. The concrete power house and the concrete pipes in connection therewith have been completed by force account, it having been found impossible to obtain reasonable bids. The machinery is of novel design and has been built especially for this plant.

At the second drop, the water is carried down through a concrete pipe about 800 ft. long, and discharged into a diffusion chamber which is provided with a wasteway. At present no use is contemplated for the power which could be developed at this point.

Water was available for the irrigation of the land on the Huntley Project in the fall of 1907.

Sun River Project, Montana.

Sun River Project is located to the west of Great Falls. The irrigable area, 264 000 acres, lies between the Sun River on the south, the Teton on the north, the Missouri on the east and the Rocky Mountains on the west. Additional area was examined during the season of 1903. During the season of 1904 surveys were extended to include the storage dam and diverting weir sites. The diverting weir site is in a canyon where the river bed is only 54 ft. wide. The weir will have a height of 72 ft. and a top length of 170 ft. Solid limestone rock extends entirely across the canyon, and there is no doubt as to the character of the foundation.

At the weir the north side diversion line starts into a tunnel, the first 1 000 ft. being through very solid limestone. From this point to Station 50 the tunnel was continued in preference to open cut because the steep hillside character of the country makes the former the cheaper, the location being carried far enough into the hill to get secure ground and cheapen the cost of con-

struction. This line has been located throughout the entire distance to Pishkun Reservoir, 13.6 miles, and while it extends through an apparently difficult country, is very satisfactory. Pishkun Reservoir has a total capacity of 45 747 acre-feet if carried to Elevation 4 370.

The Freez-Out Bench Line heads in the Pishkun Reservoir and extends eastward 23.5 miles to where it drops into Spring Coulee. The first 6.5 miles runs through a rolling glacial country; then the line is started along hillsides to reach the bench level at Station 480. In its entire length there will be two tunnels through glacial gravel. The first will have a length of 2 200 ft., and the second a length of 2 000 ft. After passing through the outlet tunnel of the Pishkun Reservoir the water for the Teton slope will run down a coulee into Deep Creek, and down this to the diversion weir, a total of 12.5 miles through natural channels. The weir as planned will be of concrete, 12 ft. high and 100 ft. long, with a 500-ft. earth embankment on the west side to confine the water to the channel. The distributing canal starts on the east side of the creek at the weir, and after the first 0.5 mile begins to serve the bottom lands along the creek, gradually drawing away to the southward.

During the past season work has been confined to the Willow Creek Dam and the Fort Shaw end. Work on Willow Creek Dam was closed down the first week in October and the equipment transferred to Fort Shaw work. Excessive snows during the winter of 1906–7, followed by a cool wet summer, insure ample water in the river for probable demands for several years. The work at this point has been as follows: Shaft sunk and timbered, 66 ft. complete ready for concrete and valve; tunnel driven and timbered, 584 ft. complete; conduit concreted, 600 ft. complete except connections for lower portal and shaft.

Work on the five divisions of the Fort Shaw canals has progressed satisfactorily with the exception of Division 3. It is expected that work on the structures of Schedule B will be completed by the end of the year. At Sims Creek Siphon, temporary office, mess house and two bunk houses have been completed. Steel and cement are on hand, and piers to support the pipe have been begun. The barrel of the pipe has been begun and it is expected that it will be completed by the end of December.

The Concrete Factory has been maintained and the pipe distributed along the canal and the culverts built ahead of the requirements of the contractors. The Canal System for the Fort Shaw Unit will be completed and water will be available for the irrigation of 16 000 acres by June 1, 1908.

Lower Yellowstone Project, Montana.

This project is located on the Yellowstone, the canal heading on the west or left bank of the river about 20 miles below Glendive and about 2 miles below the mouth of Thirteen Mile Creek. The survey was begun in August, 1903. The results show that a canal 67 miles in length will serve 70 000 acres.

Yellowstone River from the point of diversion to its mouth has an average fall of 2.2 ft. per mile. Much of the land to be irrigated by this system lies in benches 90 ft. above the river, and in order to reach it with the canal it is necessary to raise the water in the river at the head gates by means of a diversion dam and to build the canal on as low a grade as possible.

On the canal side of the proposed diversion dam the bank rises 50 ft. above the water surface of the river. On the opposite side, however, the bank is low, being but 15 ft. above low water and extending back for about 2 miles to high bluffs. The dam will be of the rock-filled timber crib type. The borings show that the river bed is a hard stiff clay for a depth of at least 50 ft. This material is excellent for holding piles. Several rows of piles will be driven across the river and the spaces filled in with large stone. The face will be covered with timber, having a slope of 3 to 1 on the up-stream side and a slope of 6 to 1 on the down-stream side.

The canal will have a capacity of 850 second-feet and a grade of 1 in 10 000. In order to obtain as great a velocity as possible with this low grade, the canal is built narrow and deep. By doing this a velocity of 2.1 ft. per second is obtained. About 25 miles of the canal is through very rough country and the work is exceedingly heavy. There are 13 difficult creek crossings, one of which is made with a double barrel pressure pipe 300 ft. long and 9 ft. in diameter. With the exception of a few hundred yards, the material excavated from the canal is all earth.

The construction work on this project is drawing rapidly to completion. The engineering work has been carried forward to keep pace with the requirements, and the organization of the Water Users Association has been perfected. The contractors are continuing to get lumber from the coast and are hauling stone from the quarry to the dam site in order that all of the material may be on the ground so that they may begin operations as soon as the ice goes out in the spring of 1908. During the past three months progress has been slow, but it is hoped that the work will be about 70 per cent. complete at the end of the calendar year.

All work will be completed and water turned into canal in the fall of 1908.

St. Mary Project, Montana.

St. Mary Project is situated in northwestern Montana. The general scheme is divided into two parts: storage of the flood waters of St. Mary River and the diversion of this water into the headwaters of the Milk River, and the utilization of the water on the irrigable lands of the lower Milk River Valley.

It is proposed to store the flood waters of St. Mary River by constructing an earthen dam at the outlet of lower St. Mary Lake. This dam, which will have side slopes of 3 to 1, a top width of 20 ft., will be 2 800 ft. long and have an effective height of 31 ft. This will give a reservoir capacity of 150 000 acre-ft.

The canal for conducting the water from St. Mary Reservoir to the north fork of Milk River will have a total length of 25 miles. The first 6 miles will be along the canyon of the St. Mary River, and about one half will be lined with concrete. The remainder is along the rolling foot hills where the construction is easy. From this point the water will be allowed to flow down Milk River through Canada and back into Montana. The water will be used to irrigate about 250 000 acres of land lying along the Great Northern Railway east of Chinook.

During the season of 1907 construction work has been carried on by force account. A 65-ton steam shovel with 2.5 cu. yd. dipper has been at work all summer near the upper end of the canal. A steam excavator with 2.5 cu. yd. dipper was placed on the lower division and continued work until the middle of October. Construction work has been suspended on this project for the winter.

[Note.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1908, for publication in a subsequent number of the Journal.]

ANNUAL ADDRESS.

By George W. Lawes, President of the Louisiana Engineering Society.

[Read before the Society, January 10, 1908.]

Mr. President and Members of the Louisiana Engineering Society: At this, the end of my official term as president of this society, I am, by mandate of the constitution and by-laws, compelled to address you. I will not take up much of your time, as, with the other business of the meeting, much has already been monopolized, and we are all impatient, I know, to see what our good friend Mr. Eastwood has in store for us in the banquet hall.

It is well, however, on this, the tenth anniversary of our existence as a society, to look back over the path we have come and see if, between the markings of the milestones, there may not be interesting things to contemplate: Things which may point out to us where we have been wise, and others which may show where we might have been wiser; and also it will be well, as we enter upon our second decade, to make plans for our future upbuilding and greater success.

In January, 1898, the charter of this society was taken out by twenty-four engineers. During the first year the membership was increased by twenty-six members, or over 100 per cent. Since then the membership has grown steadily, until to-day over one hundred members are on the roll, and amongst this membership are most of the engineers of high standing in this city and state. From 1898 to 1902 the society prospered. Interest in its affairs was taken by the members, the finances were in good shape, attendance at meetings was large and the papers presented were discussed thoroughly and interestedly. Three outings were taken, which were successful in point of attendance, and novel as to places visited, but, except the first outing of the society to the drainage plant of this city, all have been a drain on the society's treasury and have been taken at a loss financially. From 1902 to 1905 the finances of the society were at a low ebb, owing to the excessive cost of the outings, and it was a struggle to keep things going. During this period, notwithstanding the different administrations worked as hard and prepared interesting programs for the meetings, the attendance at meetings began to fall off, and has continued to.

Since 1905 the finances have improved, the stringency in our money market has been broken and we have a comfortable surplus on hand, notwithstanding an outing taken this year which cost the society $4.40.

From 1898 to date we have added largely to our library in the matter of bound volumes of engineering periodicals to which we subscribe; a few books have been donated and several technical works purchased. Except our bookcases, which are as good as new, our furniture has dwindled to a library table and the secretary's desk, and this, the secretary says, needs repairs.

In the matter of work done by the society, I think we can feel satisfied. Very few meetings have been held at which a paper of interest has not been presented, and several of the papers have attracted the attention of engineers and the technical press throughout this country and abroad.

So altogether I think we can slap each other on the back and say, "Good for the Louisiana Engineering Society!"

We want, though, at the end of the next ten years, to be able to reach, if not Excelsior, at least to show a marked advance over the ten years past. And we want to consider seriously in what way this can be accomplished. One of the first essentials, to my mind, is that each and every member must take an absorbing interest in the welfare and advancement of the organization. Without this no organization will progress. The officers may be the best, their administrative work be perfect, their efforts to secure interesting programs successful, — all will be for naught if the members do not take interest enough in the society to attend the meetings and by the magnetism of their presence instill life and spirit into the proceedings. Exceptional papers cannot be supplied for every meeting, but as a rule no member prepares a paper that he does not put forward his best effort, and whether he is successful in interesting or not, he should be made to feel that the effort is appreciated for the will if not the deed. It is very discouraging, after careful preparation of a paper, to read it to empty chairs, and the member going to the trouble to prepare a paper deserves better treatment. Come to the meetings whether you are interested in the subject or not; come because of your interest in the society, because you belong to it, are proud of it and want to aid in its progress.

The business of the society can be carried on by a bare quorum, but it is not representative business. Especially is this the case under our method of selecting officers. Officers nominated by only a few members may not, and very probably do not,

meet with the approval of a majority of the members, and it may frequently happen that the ticket that would best advance the society's interest is not chosen because the members will not take the trouble to attend the meetings and do the duty they owe as members.

Another thing, it seems to me, is that the society should have some special object or objects to accomplish. There are many things that could be done by an organization such as ours. We could become a power for the betterment of conditions where found unwholesome. Some special condition to be corrected should be taken in hand, and the influence of the society urged against it until it was righted. When that is done, take up another, and another, and in this way have something at all times for which all the members could work. What a power to accomplish things can be wielded by 100 determined men, and what an influence for good we can assert if we direct our power as a unit to its accomplishment. Without something of this kind, the members are not held together in any common cause and we become simply individuals belonging to a society, each perhaps pulling opposite to the other. We are in a position now to *do* things, which, as a smaller society, we might not have attempted, and I feel sure that from now on, the society will make itself felt in the great future progress of this commonwealth. I might mention other matters in this connection, but I will not trespass further on your time.

In conclusion, I wish to thank my brother officers and directors for the assistance accorded me throughout the year, without which I could have accomplished very little. To the Membership Committee is due the credit for the marked increase in our membership during the year, and to our worthy secretary is due much credit for hard work performed under adverse circumstances.

[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1908, for publication in a subsequent number of the JOURNAL.]

SOME OF THE ENGINEERING PROBLEMS INVOLVED IN THE CONSTRUCTION OF A DEEP WATERWAY FROM THE GREAT LAKES TO THE GULF OF MEXICO.

By J. A. Ockerson, Member of the Engineers' Club of St. Louis.

[Read before the Club, February 5, 1908.]

The remarkable revival of interest in the development of waterways, and particularly the deep-water project from Lake Michigan to the Gulf of Mexico, by way of the Illinois and Mississippi rivers, opens up questions of vast importance not only to the people of the Mississippi Valley, but to the whole country. The discussion of the methods to be employed and the benefits to accrue ought to be of unusual interest at this time. The subject covers so large a field that only a few salient points can be touched upon in the permissible limits of a paper before this club. It is hoped that its presentation here may result in a general discussion which will serve to increase the public interest in the proposed work and contribute something of substantial value toward a satisfactory, practicable solution of the problems involved in the development of a trunk line waterway between the Great Lakes and the Gulf of Mexico.

Lake Michigan to the Mississippi River.

A project for a waterway from Lake Michigan to the Mississippi River by the way of the Illinois River dates back to the earliest settlement of the country. Quite a number of surveys, plans and estimates, looking to the accomplishment of the desired result, have been made since that time.

The state of Illinois, with the aid of land grants voted by Congress, constructed the Illinois and Michigan Canal, which was opened to traffic in 1848. It begins 6 miles from the lake in the Chicago River and terminates at the head of navigation on the Illinois River at Lasalle, a distance of about 97 miles. Below Lasalle the Illinois River has been improved by locks and dams, both the state and the United States having contributed to this work. The project for improving the river provided for a navigable channel 7 ft. deep, the locks being 75 ft. wide by 350 ft. long.

When the Chicago Drainage Canal was authorized by the

state of Illinois, the project for a 7-ft. waterway was practically abandoned and the state declared itself in favor of a waterway not less than 14 ft. in depth, to be constructed by the United States from Lockport to Lasalle, the locks to be constructed in such manner as to permit of future development to a greater capacity if required.

In 1902 Congress provided for a board of engineers to determine the feasibility of constructing a 14-ft. waterway from Lockport to Grafton on the Mississippi River, and called on the Mississippi River Commission to furnish like information for the Mississippi River from Grafton to St. Louis. Plans and estimate of costs were required by the act.

In 1905 the reports were completed. The plan of the Board of Engineers proposes to canalize the river from Lockport to Utica, a distance of 63.5 miles, the fall being 136 ft. Nine locks and 5 movable dams are proposed, the upper lock having a lift of about 40 ft. The lock dimensions prescribed are 80 ft. wide and 600 ft. long, with a depth of 14 ft. over the miter sill. Concrete construction is provided for the lock walls, and the gates are to be of steel, the upper end of the channel to connect with the Chicago drainage canal at Lockport by means of a lock constructed by the Sanitary District.

The Sanitary District has already constructed a navigable canal with a depth of 22 ft. It has a length of 36 miles and constitutes a navigable channel which can accommodate the largest vessels on the Great Lakes.

The Board of Engineers were only required to consider the question of navigation; hence the development of water power in connection therewith was not discussed. If the utilization of the water power that could be developed in connection with the improvement becomes a part of the project, then a different arrangement of the locks proposed will be desirable.

From Utica to Grafton, a distance of 229.5 miles, the work proposed is to dredge a channel 200 ft. wide at the bottom, with a depth of not less than 14 ft. at low water. This involves the excavation of 27 867 060 cu. yd. of earth and 40 989 cu. yd. of rock. The estimated cost of the projected improvement from Lockport to Grafton is $23 543 582. The estimated cost of the reach from Lockport to Utica averages $241 822 per mile; from Utica to Grafton, $35 676 per mile.

The low-water slope from Utica to Grafton is about 0.14 ft. per mile, or a total fall of only 33 ft. in 229 miles.

The low-water discharge of the river at Utica is about 500

cu. ft. per sec., and this amount would be wholly inadequate for a channel of the dimensions named. The constant volume of 10 000 cu. ft. per sec. drawn from Lake Michigan through the drainage canal will, however, provide ample flow for purposes of navigation, and will also permit the development of a large amount of power above Utica. The total power that can be developed is estimated at about 135 000 horse-power, assuming a flow of 10 000 cu. ft. per sec. from Lake Michigan.

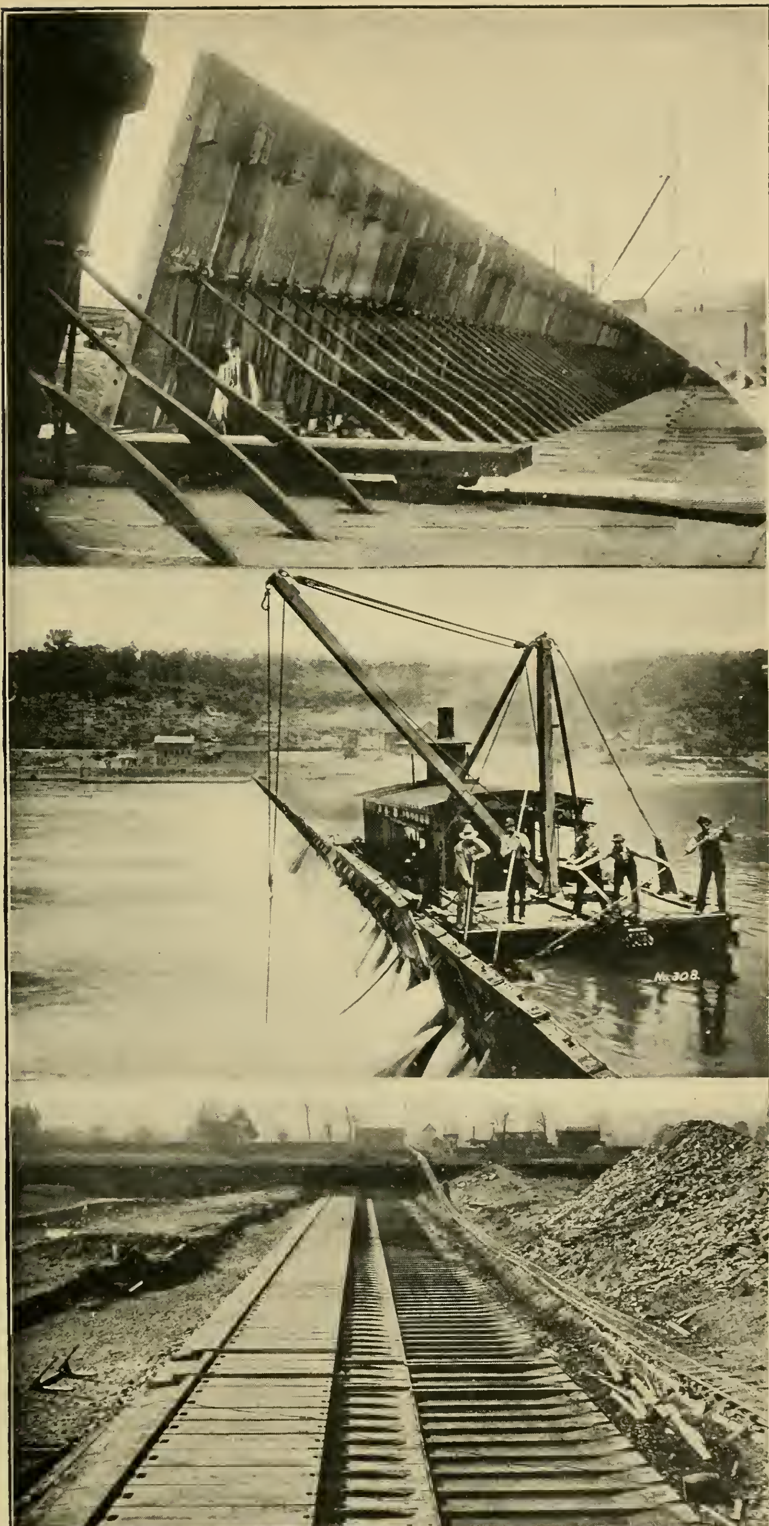
The state of Illinois proposes to undertake the whole improvement, including the water-power feature. When completed, the navigable channel will probably be turned over to the United States without charge, the chief stipulation being that the channel be perpetually maintained at the expense of the general government, the state retaining control of the water power.

Mouth of Illinois River to St. Louis.

From Grafton to the Merchants Bridge at St. Louis, a distance of 38 miles along the Mississippi River, the problem of improvement differs materially from that of the Illinois River. The Mississippi River Commission was charged with the development of plans for the improvement of this reach. The work was done by a committee of three, the writer being a member thereof. Mr. F. B. Maltby, a member of this club, had charge of the field investigations and development of details under the direction of the committee.

The Missouri River is a disturbing element in the regimen of this reach of the Mississippi. The high-water or low-water conditions in the two streams are rarely co-incident, and hence there are frequent changes in slope, acceleration or decrease in velocity, and consequently rapid and frequent changes in channel depths. The development of deep water in an open channel under such conditions presented so many difficulties, with considerable doubt as to the ultimate success of any plan along such lines, that it was finally deemed best to avoid the difficulty altogether.

The plan adopted provides for a dam of the Chanoine Wicket type, located just below the Alton bridge; a lift of 14.5 ft. forms a pool which raises the low-water surface at Grafton about 8 ft. and in which ample depth can be maintained by a moderate amount of dredging. The dam would be about 2 500 ft. long, the sill or base being a solid bed of concrete supported on piling, the top of the sill to be 3.5 ft. below the low-water mark, or not far from the surface of the natural bed of the stream. Rows of



Movable Dam such as may be used above Cairo, showing wickets raised.
Appliances for raising or lowering wickets.
Movable Dam showing wickets down. (*Courtesy of Col. Wm. T. Rossell.*)

sheet piling are provided to prevent scour beneath the dam. At high stages this dam will be dropped down and will present but slight obstruction to the free flow of water, and at such times navigation will follow the open river.

From the east end of the dam to the Merchants Bridge a canal is planned to follow along near the river, and the water surface level of the pool above the dam will be carried down to the lower end of the canal, where a lock with a lift of 30 ft., 80 ft. wide and 600 ft. long permits of the passage of vessels from the canal level to the deep water of St. Louis harbor. That is to say, with the dam in operation during the low-water period, there will be slack water navigation 14 ft. in depth from the mouth of the Illinois River to the Merchants Bridge, a distance of about 38 miles.

At the upper end of the canal, guide piers of concrete are provided to make the entrance easy. A pair of guard gates is also planned to regulate the influx of water at flood stages.

The gates, walls and embankments are to be built to a height well above the highest known floods. The canal itself is 18 miles in length. The bottom width is 160 ft., with side slopes of 1 on 2, a berm being left 5 ft. below the water surface to support a covering of riprap some 10 ft. in height to protect the banks from wave wash.

The canal is wholly in excavation, and the earth therefrom will form an impregnable levee along its entire length, and when constructed will effectually eliminate all danger from floods in that vicinity, provided similar protection is carried from its lower end down stream. Thus a large proportion of the expense involved in the thorough protection of the American bottoms from floods is provided for in this project.

The estimated cost of the work from the mouth of the Illinois River to St. Louis is \$6 553 880, or about \$172 470 per mile. This is a good round sum, but unusual difficulties are involved, and little or no doubt exists as to the complete success of the project proposed. After all, the estimated cost per mile is materially less than the cost of bank revetment alone on the lower river. Taken as a whole, the project of a 14-ft. waterway from Lockport to St. Louis can be successfully carried out as planned, or if commerce demands it, even greater depths can readily be secured.

ST. LOUIS TO CAIRO.

From St. Louis southward the deep-water problem is in the hands of a board of engineers who are actively engaged in the

investigations necessary to a clear understanding of all questions relating to the means of developing a suitable channel 14 ft. in depth. I doubt not that when their labors are completed and their report is submitted it will be found that they have worked out quite as good a solution as is presented in the projects for the improvement from Lockport to St. Louis.

The reach from St. Louis to Cairo, a distance of 180 miles, presents greater difficulties in the development of a deep waterway than any portion of the route from the Lakes to the Gulf, and the best course to pursue has not yet been fully determined. One serious feature is the excessive slope, which averages about 0.6 ft. per mile at low water, and another is the influx of sediment from the Missouri River.

It is, of course, desirable to have an open channel, free from all obstructing locks if practicable, as under such conditions the capacity of the waterway is practically unlimited. It might be that this could be attained by holding the water back by submerged dams or other regulation works, supplemented by dredging.

The total slope at low water is about 109 ft., and any method of deepening the channel involves the diminution or elimination of the slope in reaches of suitable length dependent upon local conditions. Locks and dams at suitable intervals would accomplish this result, but there is no precedent for their use in a stream so heavily charged with sediment, which might have a tendency to fill up the pools in a very short time. Whether a combination of flushing and dredging can be devised to meet this difficulty is a question worthy of serious consideration, and it is quite probable that a satisfactory solution can be reached.

A canal parallel to the river could be constructed without any serious difficulty. Its capacity would, of course, depend on its size, and this must be determined by a compromise between cost and the demands which would probably be put upon it by traffic. While the movement of vessels in a canal would necessarily be slower than in an open channel, it would be free from the present difficulties encountered in upstream navigation.

It seems probable that a combination of the three types of construction suggested, applied to different sections of this reach, will prove to be the most economical and efficient solution. With the volume of water available at the lowest stages, augmented as it will be by the addition of 10 000 cu. ft. per sec. or more from the Great Lakes, there is little or no room to question the feasibility of developing and maintaining, by adequate means,

a navigable channel not less than 14 ft. in depth. Whatever the project adopted may be, it will necessarily involve more or less bank protection and dredging.

The project under which improvement work has been carried on in this reach provides for the development and maintenance of an 8-ft. channel at all stages except when the river is closed by ice. The construction work embraces bank revetment, contraction of channel by means of dikes and low-water dredging. All of this work has been successfully prosecuted for a number of years, so far as the appropriations would permit. A thorough examination made during the low-water season of 1907 showed a navigable channel 8 ft. in depth.

Cairo to the Gulf of Mexico.

From Cairo southward the problem of deep-water development changes again. Here the river enters the great alluvial basin and flood control becomes an essential feature of any plan of improvement.

The low-water volume which at Utica is 500 cu. ft. per sec. omitting the lake contribution, at St. Louis 40 000, here becomes over 70 000 cu. ft. per sec. at low-water, and 1 600 000 cu. ft. per sec. at high water. The low-water slope from Cairo to Red River averages 0.35 ft. per mile, or about one half the average slope from St. Louis to Cairo.

Under natural conditions, without improvement, a navigable depth of 14 ft. is available for six months or more each year, even in exceptional low-water years. The obstructing bars which would require deepening to 14 ft. lie between Cairo and the mouth of the Red River, a distance of 765 miles. The 300 miles of river below the mouth of Red River has ample depth at all seasons of the year, even for ocean vessels.

The improvement below Cairo is under the control of the Mississippi River Commission. Under the present project the work consists of the construction of levees for the control of floods, the maintenance of a channel "not less than 9 ft. in depth at all stages except when closed by ice," and the revetment of banks for the purpose of preventing cut-offs through narrow necks of land, the protection of important levees and the water fronts of cities.

Flood Control.

The levees now reach a length of about 1 450 miles. The several states have had the largest share in the cost of their

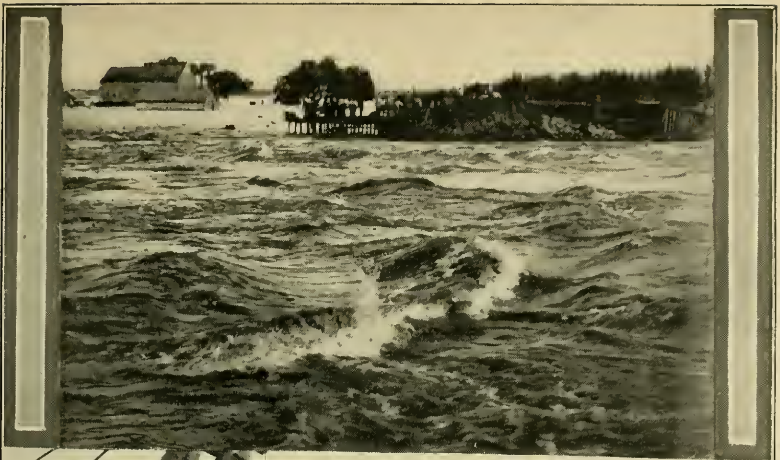
construction. The character of work required is fixed by the plans and specifications prescribed by the Mississippi River Commission.

The levee system is by no means complete, either in height or section, yet it affords a good measure of protection. This is shown by the fact that the flood of 1907, which has only been exceeded six times in the past 40 years, and reached within 1.8 ft. of the highest recorded flood, was carried down for 975 miles without a single break in the levees. The development of the Alluvial Valley due to such protection has been little short of phenomenal. In a brief space of time the tangled wilderness has given place to fertile fields, and many thriving towns and villages have sprung up.

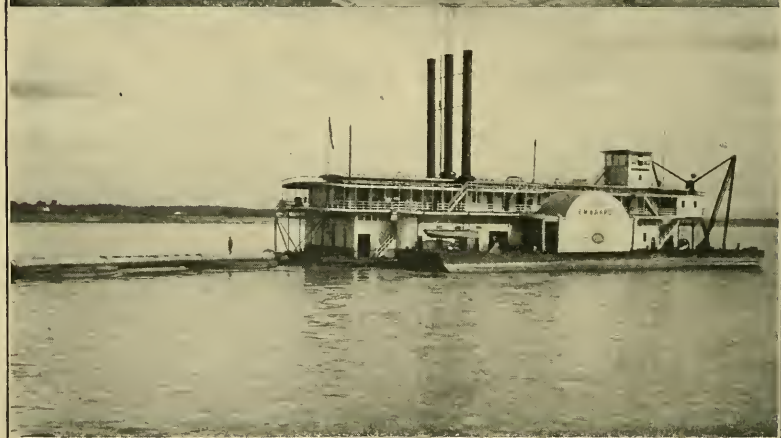
Dredging for a Nine-Foot Channel.

The dredging work required to maintain a 9-ft. channel is almost entirely confined to the first 250 miles below Cairo. There are only about 40 bars or crossings in the entire reach, Cairo to Red River, which may develop shoals with less than 9 ft. thereon. They have never been known to be shallow at the same time, and it very rarely occurs that even one half of them become obstructions to navigation in any single low-water season. The largest number of bars dredged in a season down to date is 17. During the last three years only 5 bars have required dredging each year, and but few of the bars show lack of depth at the same time. A crossing with deficient depth one year may have ample depth for several years in succession. As a general rule, shallow bars are looked for in a few well-defined localities each season. A very large percentage of the 765 miles shows depths of 9 ft. or more at all stages, leaving a comparatively small amount with deficient depth which must be increased by artificial means. Furthermore, the duration of the low-water period, when the depth may be deficient, does not exceed five months in the year as a maximum, and is more often covered by a period of three months.

Under the project cited, little difficulty has been experienced during the past six years in maintaining a 9-ft. channel by means of dredging. The Mississippi River Commission has 9 available dredges, but only 5 of these have been needed during the low-water seasons of the past 5 years. The work required to maintain a channel varies greatly with different seasons, but it does not depend wholly on the variations of stage. The vertical oscillations of the bed of the river itself conform in a great meas-



A Break in the Levee below New Orleans.
Levee-building Device with 2½ yd. Scraper Bucket.
Levee built therewith.



Closing Crevasse in Levee.
Pile Work finished and Cribs being filled in.
Latest Hydraulic Dredge. Capacity, 1 600 yd. per hour. Discharge pipe, 36 in. diam.
Suction head, 32 ft. wide.

ure to the changes in stage. A channel 10 ft. deep at a 10-ft. stage may still have 6 ft. or more in depth after a fall of 8 ft., or there may be even a less depth at a higher stage.

It will be seen, therefore, that the problem of maintaining a deep channel in a silt-bearing stream is somewhat complicated, in that it is impracticable to determine beforehand how much work will be required in any low-water season.

Experimental Dredging for a Deep Waterway.

The Mississippi River Commission has had three dredges at different crossings during the past low-water season, testing the practicability of developing and maintaining depths of 14 ft. or more by means of dredging. So far as the experiments have gone, the indications are decidedly favorable. Channels of such depth have been developed and maintained without difficulty.

The dredging for channels 14 ft. in depth was done at Linda, 82 miles below Cairo; Island 35, 192 miles below Cairo; and Corona, 204 miles below Cairo, and the following results were obtained:

Linda was dredged three times following changes in stage, and a 16-ft. channel was developed and maintained.

Island 35 crossing was dredged four times, giving a channel depth of 17 ft.

At Corona the dredge cuts were from 7 to 12 ft. in depth and channel depths of 16 ft. were secured.

It is proper to say, however, that the low-water conditions during the season were not such as to require a great amount of dredging, as the river was somewhat above the normal summer stage.

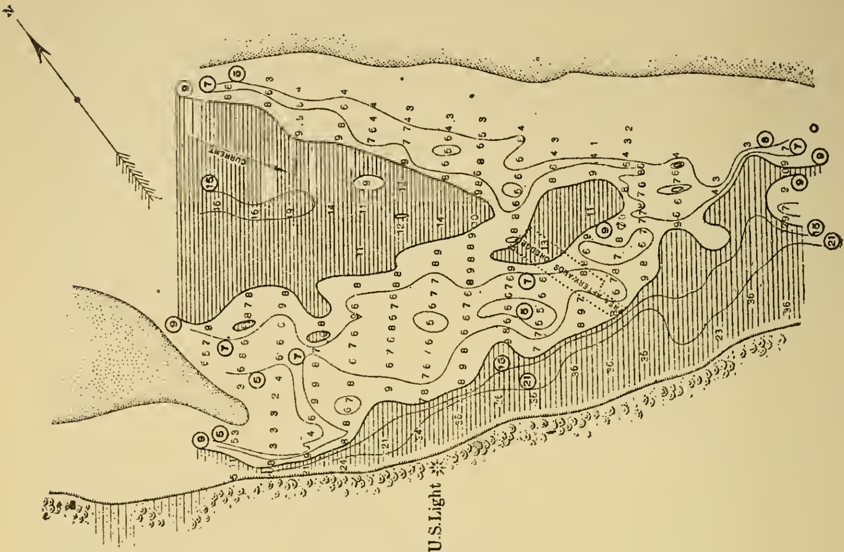
Normal Channel Conditions.

There is not a foot of the entire length of the river from Cairo to the Gulf of Mexico which has not depths of 14 ft. or more at all stages in some portion of the cross-section. That is to say, the pools overlap one another and are separated by the obstructing bars or crossing.

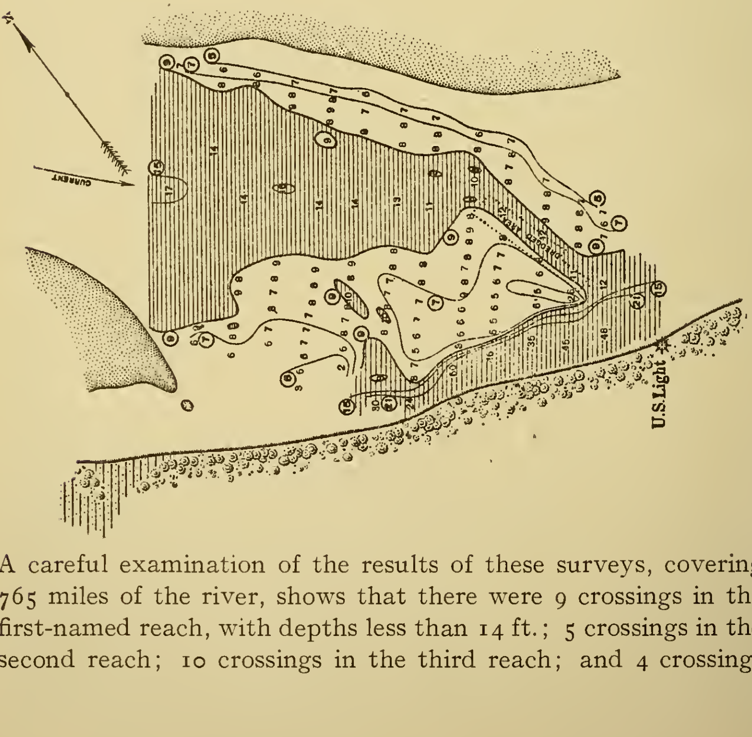
Just what depth may be found on any crossing at low water can only be determined by actual soundings at low-water stage. It must be apparent, owing to the shifting character of the river bed, that soundings taken at higher stages and reduced to low water would be greatly misleading and of no value in deducing low-water depths.

Surveys were made during the low-water season from Cairo

to Corona, 203 miles, in 1902; from Corona to Arkansas River, 198 miles, in 1904; from Arkansas River to Vicksburg, 198 miles, in 1894; and from Vicksburg to Red River, 165 miles, in 1895.



Bar or Crossing before Dredging.



The Same Bar or Crossing after Dredging.

A careful examination of the results of these surveys, covering 765 miles of the river, shows that there were 9 crossings in the first-named reach, with depths less than 14 ft.; 5 crossings in the second reach; 10 crossings in the third reach; and 4 crossings

in the fourth reach; or a total of 28 crossings, with an aggregate length of 43 200 ft., or a little over 8 miles and about one per cent. of the total distance. Had the surveys of the two first-named reaches been made during the extreme low-water seasons of 1894 and 1895 when the other two reaches were surveyed, there is little doubt that a greater number of deficient crossings would have been found.

An investigation made in connection with dredging during the lowest water of the season of 1904 showed 33 crossings with depths less than 14 ft. between Cairo and mouth of Arkansas River. This number would be excessive, if anything, as no special effort was made to follow the line of deepest water.

The lowest stages so far recorded occurred during the years 1894 and 1895 and the low-stage conditions were prolonged. The 14 crossings, showing less than 14 ft. in depth between the mouth of the Arkansas River and Red River, may, therefore, be regarded as representing extreme low-stage conditions. It may be said further that only four crossings between Vicksburg and the Gulf of Mexico, a distance of 470 miles, showed depths less than 20 ft.

In view of the foregoing facts, it does not seem probable that the total number of crossings or bars below Cairo with channel depths less than 14 ft. will ever exceed 45 in number in any one year. Assuming an average length of a mile each, which is undoubtedly excessive, the aggregate length would be about 4.2 per cent. of the total distance. So the elimination of these bars by means of regulation works and dredging cannot be regarded as an exceptionally formidable task.

There has been a good deal of speculation as to the effect of dredging through a bar in lowering the pool above. If this actually occurred to an appreciable extent in a succession of bars and pools, it might become serious. The most careful measurements, however, fail to disclose any such results.

Little or no enlargement of the cross-section of the stream occurs, as the overlapping portions of the pool sections are largely eliminated by connecting them with a dredged channel.

Bank Erosion and Its Prevention.

By far the greatest source of supply which contributes to the development of sand bars in the lower Mississippi River is the erosion or caving of the banks. The volume of solid material per annum from this source amounts to an average of 9½ acres 66 ft. deep for each mile of river between Cairo and Donaldson-

ville, a distance of 885 miles, or over a million cu. yd. for each mile of river, a quantity quite sufficient to account for all of the sand bars; and it is hardly fair to charge the Missouri River with furnishing all or even a very large percentage of the material that contributes to the obstructions to navigation between the mouth of the Ohio and the Gulf.

In the reach below Cairo the development of a deep channel will necessarily include the fixing of the badly caving banks, and this will doubtless prove to be the largest item of expense. The work of the Mississippi River Commission, extending through a number of years of experimental work, has developed a type of revetment which is found to be equal to the task of holding caving banks even in the most difficult bends of the river.

The problem presented is by no means an easy one. The banks often extend 40 ft. or more above low water, while the thalweg of the river bed lies 60 ft. below the same. Thus we have a saturated bank about 100 ft. high resting on a base of silt which is readily moved by the rapid current. Comparatively slight obstructions to the current cause whirls and eddies which are destructive in their effect, sometimes undermining the revetment, unless it is carried well out into the stream.

Experience developed the necessity of wide mattresses, 300 ft. in width in some cases, instead of 100 ft. as used in the earlier work. It also proved that spur dikes at intervals of 450 ft. cannot be relied upon to hold the banks without continuous revetment between. To be effective the interval must be so small that their use is no longer regarded as advantageous or economical.

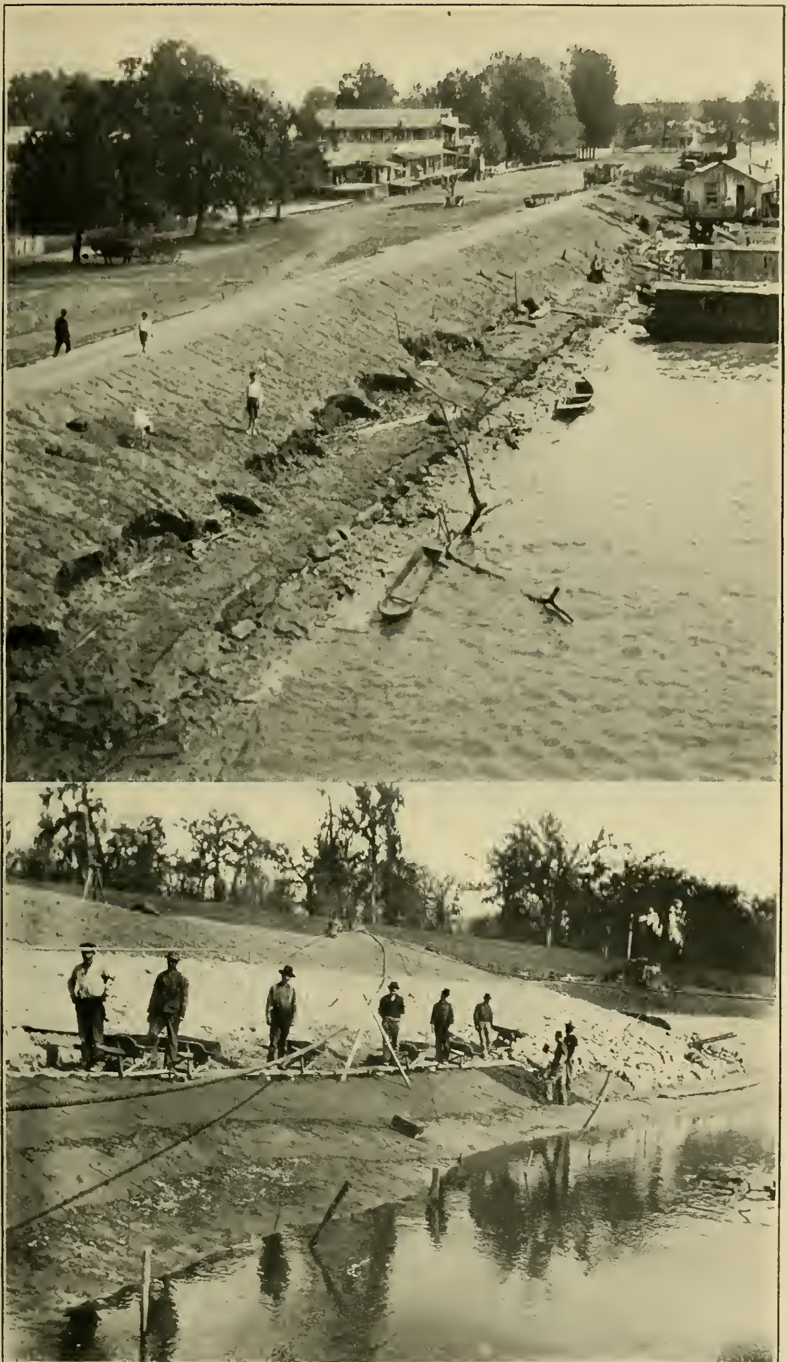
The standard revetment as now used consists of a mattress of willows heavily weighted with stone, covering the bank from near the low-water line down. The upper bank is graded to a slope of 1 on 3 by means of hydraulic grades, and is then paved with stones laid upon a layer of spalls.

This type of revetment can be relied upon to hold the banks in the most difficult situations. It is manifestly not permanent in the sense that it will need no care after it is put in. Like most engineering or other structures, revetment must have constant care, but if properly placed in the first instance the cost of maintenance will not be excessive.

In New Orleans harbor the length of revetment is over five miles, some of which has been in place more than 20 years, yet there has been nothing expended in repairs and maintenance direct, other than that chargeable to plant and administration.

Caving Bank and Revetment Plant. Weaving Mattress for Bank Protection.

Revetment to Protect Levee from Wave Wash.



Wave Wash at Base of Levee.
Paving the Upper Bank.

Upper Bank Paving in Bank Protection.
Mat Weaving for Bank Protection.
Grading Down the Bank Preparatory to Paving.

This revetment consists of spur dikes at intervals of about 450 ft., with standard revetment between.

The total length of revetment in place below Cairo to date is 39.6 miles. The repairs and maintenance, including all charges, varies in different localities, from less than one to about five per cent. of first cost. The latter figure may be regarded as quite excessive and will no doubt be largely reduced by the present methods of construction. Efforts are now being made looking to the development of longer field seasons whereby the plant can be used for a longer period each year, the result of which would be a material reduction of cost. Heretofore the field operations have been confined to the low-water season of three to five months.

The experience gained in this work is a most valuable asset, but it has been at the expense of much time as well as money, and the element of time is the more important of the two. Before a work can be looked upon with any degree of confidence it must pass through all the cycles incident to changes of stage, which necessarily requires many years, and this test cannot be hastened by any known means. But with the experience acquired by many trials, supplemented by careful, systematic observations, we can now proceed with confidence in our work, feeling sure that it will meet the requirements in a satisfactory way.

Character of Works Required.

There will be no great difference of opinion among those who are familiar with the conditions as to the general plan to be followed in the development of a deep waterway below Cairo. The essential features must be, a combination of flood control by means of levees, bank protection, dredging and a limited amount of contraction work where the channel width is excessive. The proper use of such works will develop a deep-water channel at all stages of river throughout the lower two thirds of the proposed " Lakes to the Gulf " waterway. In this reach the physical conditions are thoroughly understood, the means to be used have long since passed beyond the experimental stage and a fair estimate of the cost of a channel of such depth as may be required can be made from the data now in the possession of the Mississippi River Commission.

It would, therefore, seem to be good policy to begin systematic work on this reach at once, looking to the development of such depth of water as may be deemed necessary to meet the future demands of commerce. The organization is ready, a

large portion of the plant needed is on the ground and it is only necessary to decide as to the limiting depth, when the work could proceed systematically on the lower thousand miles of the waterway pending the results of the elaborate investigations required for the 180 miles between St. Louis and Cairo.

Since the unanimous declaration of the Illinois legislature in favor of a bond issue for the construction of a deep waterway to the Mississippi River at Grafton, 329 miles from Lake Michigan, and the fact that good results are practically assured for the lower 1 070 miles below Cairo, it does not seem at all probable that such formidable obstacles to the proposed improvement between St. Louis and Cairo, 180 miles, will be met with as to seriously menace the practicability of the entire project.

The work required from Grafton to St. Louis with estimated cost has also been definitely determined. So, out of a total distance of 1 625 miles from Lake Michigan to the Gulf of Mexico, there are only 180 miles concerning which there is much doubt as to the best methods of securing the depth desired, and even in this limited reach there can be no reasonable doubt as to the possibility of securing such depth as may be required.

The opening of the Panama Canal should see the work on the deep waterway well on toward completion, and it would seem to be wise to begin work at once, since the proper line of procedure for more than two thirds of the entire work is already quite clearly defined.

Ample Terminal Facilities Essential.

The easy and expeditious transfer of freight at the great shipping centers is quite important. The lack of facilities therefor has been attributed to the difficulty of installing suitable terminals on account of the oscillations of stage in the river. The extreme range of stage recorded at St. Louis is 44 ft.; Cairo, 53 ft.; Memphis, 43 ft.; Vicksburg, 59 ft.; Natchez, 51 ft.; New Orleans, 21 ft.

While these conditions complicate the problem somewhat, there are no great difficulties in the way of designing and constructing fireproof warehouses along the river fronts which would greatly simplify the loading and unloading of boats and barges and provide for the interchange of traffic with the railways direct without the usual drayage.

Some years ago the writer suggested the construction of a series of warehouses along the river front at St. Louis, beginning at the Eads Bridge and extending downstream as far as neces-

Part of Harbor and Wharf at St. Louis.

sary to accommodate the traffic, the warehouses to have several floors for the convenience of the water traffic, the surface and elevated roads, and goods that came by wagon, all to be provided with suitable elevators, which could shift loaded trucks from one floor to another, where they could be rolled away to the desired point of delivery. Suitable conveyors, inclined and horizontal, would also expedite the handling of freight. These warehouses were to be reached from the business portion of the city by elevated driveways, which would eliminate a large part of the steep hill between Third Street and the levee. The great value of such terminals to both water and rail traffic must be apparent.

The city of New Orleans has actively begun the construction of extensive warehouses and freight platforms along the river front, with a belt line of railway along the land side thereof, for the easy and rapid interchange of freight. Her example should be followed by other important shipping centers in order that the fullest benefits to be derived from water transportation may be realized.

At St. Louis and other points, wharf boats rising and falling with the stage of river have been in common use, but the drayage over the steep levee has always been a serious drawback. This method does not permit of a direct interchange of freight with railways, as the wharf boat moves laterally along the slope of the levee as well as vertically, as the stage of the river changes.

Warehouses, called elevators, for handling package freight, were formerly used with success at Memphis, Vicksburg and Natchez; and at New Orleans conveyors are now used to carry the freight to the top of the wharf or levee.

For facilitating loading or unloading at way landings, river craft should be provided with conveyors attached to the stage plank so that freight could be landed at the top of the bank without using the great amount of time and labor incident to present practice.

Where the cargo is destined to foreign ports, the transfer can be made direct from river to seagoing craft, and in this way storage and warehouse charges would be materially reduced.

Improvements of the kind named are next in importance to better channel conditions and in a general revival of river traffic should receive the fullest consideration.

Value of Waterway as a Transportation Highway.

As the deep-water project proposed will involve the expenditure of large sums of money, it is proper to inquire as to what

benefits may be expected to accrue by its construction and use. Before any project is adopted, it should be pretty clearly established that the sum of all the benefits will be fully commensurate with the cost. When this has been satisfactorily settled, the cost of the project, though great, becomes a matter of secondary importance.

In a project of such great magnitude, these questions of cost and value, especially the latter, cannot be determined with any great degree of exactness. The same thing is true to a certain extent of all great engineering works, —the Suez Canal, the Manchester Ship Canal, the great transcontinental railways, the New York subways. In all of these cases the benefits that justified the works could only be roughly estimated when the projects were undertaken, and in nearly all of them the estimates of the benefits were altogether too conservative. And it is not improbable that the value of a trunk line waterway of great capacity, such as proposed, will also be underestimated even by its most enthusiastic advocates.

The writer devoted considerable time to gathering statistics of the freight movement by river and by rail from the port of St. Louis for the years 1865 to 1900. These data were published in the report of the Mississippi River Commission for the year 1901 and have been widely quoted since that time.

The grain traffic by river did not assume important proportions until 1877, owing to the general belief that grain exported by the way of the warm, humid Gulf route would be damaged in transit, although the St. Louis Grain Association virtually settled the matter in 1869 by sending 500 000 bushels of wheat to Liverpool, which reached its destination in good order. The lack of depth at the mouth of the river prior to the construction of the jetties was also a serious drawback.

The maximum rate on wheat by rail from St. Louis to New York reached 72 cents per bushel in 1867. In 1877 the rate was 24.6, and in 1900 11.6 cents per bushel, as against 8¼ cents in 1877 and 4¼ cents in 1900 from St. Louis to the seaboard at New Orleans.

From the exports for 18 years, 1883 to 1900 inclusive, for which complete data are available, some interesting deductions may be made. The total number of bushels of grain exported from St. Louis during this period was 761 004 715 bushels. The average rate per bushel, St. Louis to Liverpool by river and Gulf route, was 6.85 cents less per bushel than that by rail via Atlantic ports. Applying this to the total amount exported, and we have

the magnificent sum of $52 128 882.98, which might have been saved to the producer and shipper had the grain been carried by the river route. The river did actually carry 134 736 563 bushels of export grain during this period, showing an actual net saving over the rail rates of $9 229 454; this from a single port on the river and for a single commodity.

Add to this the shipments that were made of coal, lumber, cotton, sugar and general merchandise to and from this and many other ports throughout the length of the river, and we get some conception of the enormous value of the Mississippi River as a commercial highway under such improved conditions as would insure ample depth at all times.

Two illustrations will perhaps serve to emphasize the possibilities of river traffic. The steamer *Sprague*, a stern-wheel towboat of the Mississippi River type, has recently taken down at one time a cargo of 67 000 tons of coal. A recent report of the Frisco Railroad gives the average car load for the past year at 16.9 tons, and train load, 224.4 tons. On this basis it would require 3 965 cars or 298 trains to haul the single cargo named.

A notable cargo on a single hull was that of the *Henry Frank*, which carried 9 226 bales of cotton and a quantity of cotton seed at a single load. The hull of this boat was 267 ft. in length, with a beam of 52 ft. This single cargo would make about 300 carloads.

Both of these cargoes were carried at high stages of river, but they afford good illustrations of what might be done with an improved waterway with sufficient depth at all seasons.

There is a wrong impression in the popular mind as to the relative speed of transportation by water and rail. The *Sprague*, with her immense cargo in barges, would make 75 to 100 miles per day, or about four times the average speed of freight movement by rail, as given by a high railway authority.

A cargo on a single hull would easily average 150 miles or more per day.

The usual time for a tow of grain barges carrying about 12 000 tons, or say 54 average train loads, from St. Louis to New Orleans, is 8½ days, or an average of 140 miles per day, over five times the average rate of freight movement by rail.

Whatever may be the type of boat that will ultimately ply between the principal ports and the seaboard through a deep waterway, the way landings must continue to be served in a large measure by boats and barges similar to those now in use.

An improved waterway which would develop to the highest

degree the possibilities of water transportation would largely solve the question of freight congestion under normal business conditions, which has become a matter of such serious concern to railway managers. As an illustration of this congestion, it is related that an English firm of spinners bought last year at Memphis some 5 000 bales of cotton to be shipped to Liverpool via Atlantic ports. Such was the dearth of cars that the cotton remained in storage three months before it could be started on its way.

The waterway must supplement the railway by relieving it of a large volume of the low-class freight, such as farm products, coal, lumber, minerals and building material, leaving the manufactured products and higher class freights to the railways.

Raw material can be moved cheaper by water than by rail, and much that would otherwise remain inert would be brought into use to be developed into manufactured products, the distribution of which would result in increased revenues to the railways. So it is by no means unreasonable to assume that an efficient waterway will be of substantial benefit even to the railways.

Special Advantages of the Route from Lake Michigan to the Gulf of Mexico.

First. Its whole length lies in the very heart of the most productive section of the entire country.

Second. The great capacity of three fourths of its length as a transportation highway is without a parallel. As compared to the greatest artificial highway, it has practically unlimited capacity.

Third. Its situation as to closure by ice gives it a very decided advantage over any of the northern routes proposed. One thousand miles of its length is open to navigation practically the entire year. Even between St. Louis and Cairo the river was open 20 out of 43 years, and the closure on account of ice in the most severe winters has never exceeded 59 days. The northern routes are generally closed more than twice that length of time each year.

Fourth. The volume of water available under natural conditions, which is essential to the development of any satisfactory waterway, is far greater than that of any other route, and its capacity for improvement is proportionately greater.

Fifth. The proximity of the Gulf end of the route to the Panama Canal and the consequent advantage in trade with the

Pacific coast and the Orient, as well as the accessibility of the South American countries, gives this route a great advantage over any other in this particular field of trade and commerce.

Sixth. Its construction, in proportion to its available length and capacity, will probably cost less than any other route.

Seventh. Nature has marked a route of unequaled utility and value along the thalweg of the Mississippi Valley which the skill of the engineer can readily bring under subjection for the profitable uses of man.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1908, for publication in a subsequent number of the JOURNAL.]

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WIRELESS TELEGRAPH AND TELEPHONE.

BY THOMAS E. CLARK.

[Read before the Detroit Engineering Society, December 20, 1907.]

PROGRESS seems ever to be the watchword of the human race. Man is never satisfied unless he is improving on the things already done. Long before the dawn of the Christian era wireless methods of transmitting intelligence to a distance were employed. Such telegraphing, of course, was not electric, but did, nevertheless, communicate through space. The ancient Greeks had adopted a systematic method of signaling with torchlight placed on high walls, certain combinations of these signals representing certain letters of the Greek alphabet. Many remarkable instances of the mysterious powers said to be possessed by the Eastern nations of sending messages through space hundreds of miles without visible appliances have been brought to my attention in reading the history of wireless communication.

There is no doubt that many here present at one time or another have been made familiar with remarkable phenomena that could be explained in no other way than by one mind acting on another mind. To say that all are the result of coincidences would be absurd. If we do not understand certain at present inexplicable phenomena, let us at least be logical and maintain open minds, and not discredit the efforts of those who know more than ourselves.

We are surrounded with mysteries, while our vision and all our other powers are limited. There are forces and forms of

energy, undreamt, awaiting investigation, and many of them doubtless would be beneficial to the human race if we could only lay hold of them. The discovery of the X-rays is an indication of this. We have had X-rays present for many years in all experiments where high-frequency currents of electricity have been applied to Crookes tubes, yet we never realized the fact that such an aid to medical science was so close at hand. The whole nature, power and virtues of the beam of light are not yet known and so it is with many of our surroundings.

Right here I want to touch on the question, Is there anything solid? There are three or four different methods adopted by scientific men for signaling through space without metallic conductors or connecting wires, and it is evident that if we are to understand any of them we must considerably modify our ideas of the compactness of solid bodies. It becomes a question whether there is any substance so absolutely compact that there are no spaces between the atoms into which the thin medium may enter. Our idea of the opacity of wood, ebonite, aluminum, etc., underwent a complete change on the discovery of the X-rays; so it is with regard to everything that unscientific people have been accustomed to look upon as absolutely solid or compact. It is not easy to give up old ideas.

When we place a wireless transmitter or sending instrument in one room and a receiver in another room, and the electrical energy immediately passes through walls, partitions, etc., our ideas of the matter of solid bodies and compactness all receive a sudden shock and the layman wonders what we are coming to.

A few simple illustrations will help us to see that bodies which we look upon as perfectly compact must have spaces or interstices between their atoms, however close we may imagine those atoms to be together.

Suppose, for instance, that we cut down a large tree of the forest, cut off its branches and take a length of 200 ft. of immense circumference and weight of many tons; still it is not truly compact, for its atoms are separated by space. If we take a pin and gently scratch one end across the grain, so gently that we cannot hear the sounds of the scratching at our end, a friend at the other end will distinctly hear the sounds produced and will be able to tell us the exact number of times we used the pin. To do so he need not put his ear against the tree, for he can hear distinctly several inches or a foot away from the end of it. The gentle scratching with the pin has set every atom and molecule in the tree in a state of rapid vibration. The pressure of the

pin may not have been more than half an ounce, yet it is sufficient to cause such an alteration in the huge mass that waves of sound are rapidly conveyed all through it.

If there is nothing absolutely solid in nature, it follows that it is possible for a medium possessing certain qualities to permeate all things. We have the strongest reasons for believing that such a medium exists. Now we have to see how the ether is of service in the discoveries and work we have under consideration.

If a stone is thrown into the middle of a pond, a series of ripples, or small waves, covers the surface of the water. Similar waves are produced in the air whenever a bell is struck; and the ether has its waves also.

Faraday, Helmholtz, Clerk Maxwell and others have stated that light from the sun and electricity were the same in kind and that they only differed in degree, the difference resting in the lengths of their respective waves. Their velocity through space was the same, namely, 186 000 miles a second. Hertz actually proved in his laboratory that electro-magnetic waves were capable of reflection and that they were longer than those of light. This paved the way for surprising results, as we will notice later. Energy sent out from the sun receives different names. For example, we have light waves, heat waves, electric waves and so on.

It is a common mistake to credit the vibrations in air with doing the work done by the vibrations in the ether. We must draw a very wide line between the two kinds of vibrations in all experiments and work associated with wireless telegraphy. One set of vibrations, those in air, has to do with, it may be, thousands of waves per second, but those in the ether are reckoned by hundreds of millions, hundreds and even thousands of billions per second. We may easily see the difference in the behavior of the two media, air and the ether.

Suppose in a thunderstorm three miles away we see a flash of lightning; the light-waves in the ether reach the eye practically at the same instant that the flash actually occurred, because, if light be capable of traveling round this earth about eight times in one second, it would not take the sixty-thousandth part of a second to travel three miles. But what about the noise occasioned in the air by the electrical discharge? Noise or sound has to do with the other medium, namely, air, and its reception is accomplished by the ear, not the eye. The waves in the air do not travel at the same pace. The average speed

may be about 1 150 ft. a second, according to the temperature of the air. This would mean about fourteen seconds for the thunder to make itself known to us. The electric current in fourteen seconds would have gone round the earth more than a hundred times.

Another illustration may not be amiss here: A skeleton clock, with hammer and bell visible, and wound up to keep ringing for a considerable time, is placed under the glass receiver of an air-pump. As the air is pumped out the sound gradually gets weaker; we see the hammer striking the bell, but the sound is almost *nil* as the exhaustion approaches a vacuum. You cannot have sound if there be an absence of air, for there is nothing to set into vibration by the vibrations of the bell, which has been set into vibration by the action of the hammer. But there is a medium present which cannot convey sound-waves, that is, the ether. It is there, otherwise I should not be able to see the clock. This is made visible to me by the light which reaches the eye. The light waves do not require the medium air, but ether.

In accompanying scales of vibrations we see the great line of difference between waves in air and those in the ether. First we note the ordinary range of human vocal powers, including those of professional singers, and observe the wonderful range of the powers of human hearing.

Vibrations in Air and in the Ether.

THE ETHER VIBRATIONS PER SECOND.

Probably trillions		The "X-Rays."
2 000 000 000 000		Actinic rays.
750 000 000 000 to about 400 000 000 000	violet indigo blue green yellow orange red	The range of human sight.
100 000 000 000		Infra red.
230 000 000 (approximately)		Hertz waves.

AIR (SOUND) VIBRATIONS PER SECOND.

Range of human hearing	40 000	Highest audible sound.
	30 000	The shrill cry of bat.
	4 000	Highest musical note used.
	2 000	High soprano note.
	512 to 256	Woman's conversational voice.
	128	Man's voice (conversational).
	32	Lowest musical note used.
	16	Lowest audible sound.

To proceed now to the other set of vibrations, those in the ether, we are struck with the limited range of the human eye. It reaches from four hundred billions (violet). But what a wonderful power, the power to see, the power to appreciate color! Next to the right use of the mind comes in order this power to see. The ether is the medium, light the agent and the eye is the receiving instrument. The adaptability of the eye to light is a marvel in itself. But even if the eye be limited in its range, what does it matter? The mind of man applies itself, and other rays, invisible to his eye, are discovered and utilized in ways that are beneficial to mankind. Thus the mind, when properly applied, is capable of discovering in the beam of light blessings that have lain dormant probably throughout all previous time. And, as already stated, we have not found out yet all that may be known about, or all that may be contained in, a beam of light. For a certainty we have not found out much about the ether. But what little is known leads us to expect great things in the near future. By it we may yet understand a great deal more of the mysteries of gravitation and cohesion and obtain clear perceptions of the causes of the phenomena that are now very puzzling to us.

The ether conveys energy from the sun in the form of waves. These waves vary in length. To one set we give the name of *light*, and the eye is adapted for the appreciation of those waves. The surface of the body appreciates or feels other waves, to which we give the name of *heat*. Other waves are detected by delicate instruments, and to them we give the names of *electricity* and *magnetism*. As the eye receives light, so, Lord Kelvin says, the delicate coherer of Branly has an "electric eye," in that it is sensitive to electric waves of the Hertzian series. We speak nowadays of energy taking on the form of waves, and though electric currents are said to "flow" along wires, the expression is hardly accurate enough, as it flows in the medium surrounding the wire.

Although there is such a wide difference in rapidity between waves in air and those in the ether, there is a certain parallelism in their requirements and their behavior; so much so that for purposes of practical demonstration we use experiments with waves of air to illustrate those in the ether; hence the same terms are applied in each case.

This brings us to the law of sympathy, or "syntony," for us to understand which, as it is applied to wireless telegraphy, we must see its bearing upon musical instruments and in fact

upon anything that can be made to vibrate. It is well known to musicians that if a violin and a piano be in the same room, and if they are tuned to each other, as if about to be used in a duet, a note sounded on the violin will find a response in the piano, if the dampers be raised from the strings by putting down the pedal. It is useless to try to hear any result without previously tuning the violin.

In all wireless work or experiments carried out a system of " tuning " must be resorted to in order to establish perfect unison between the receiving apparatus and the transmitter. Yet the tuning does not refer to " sound " at all. The sympathy cannot exist between the two main parts of the apparatus when removed far from each other unless one be tuned to the other.

Before proceeding with a demonstration of the wireless telegraph instruments, an explanation here will assist us to understand it more clearly. Wireless telegraph is much more simple than is ordinarily supposed. The layman and the business man give the subject little thought or attention. It is my intention to briefly explain the subject as it presents itself, as free from technical language as possible.

The method of sending wireless messages is very much like the transmission of sound. In sound, the human voice, or whatever makes the sound, sets up vibrations in the air, which are carried in a wavelike motion until they strike the ear. The voice, or whatever makes the sound, corresponds to the transmitting instrument in wireless telegraph and the ear to the receiving instrument in wireless telegraph. The main difference between the two is that in the one the vibrations are set up in the air instead of in the ether. Ether, as I explained a few moments ago, is believed to fill all space and to lie around the smallest atom or molecule in any substance. Accordingly, sound in ether travels in wavelike motion, going through solid substances; and thus wireless telegraph messages can be sent through brick walls, etc. In wireless telegraph it is necessary to set up vibrations in ether in sufficient quantity and to provide a wireless receiver sensitive enough to record the vibrations. When a violin string gives out a note it vibrates back and forth, causing the air to vibrate to the same wave-motion.

In transmitting a wireless message, an electric condenser is made to discharge, oscillating back and forth many thousand times per second across a small air gap. The vibrations in ether thus produced travel in all directions from the aërial wire attached to the sending instrument and supported by the verti-

cal mast at the transmitting station, and some of them will impinge upon the corresponding antennæ wires connecting the receiving instrument at the receiving station. Since the receiving wires are good conductors, a number of these ether waves, called electric waves, will be collected and led down to the receiving instrument somewhat the same as with the human ear, which collects the air vibrations and carries them down to the ear drum.

When the electric wave impinges upon the vertical antennæ wire and reaches the Clark Wireless Telegraph receiving instrument known as a detector, the effect is to vary the sensitive electrical resistance in the local circuit which contains the detector. This causes a disturbance or sound in the receiver connected in the receiving circuit. The electric waves in the ether continue to come into the receiver, traveling at the rate of 186 000 miles per second, as long as the operator at the transmitting station holds his transmitting key down, and just so long a sound is heard by the receiving operator, who takes down the message in dots and dashes of the Morse telegraph alphabet just as fast as they are sent by the transmitting operator, the receiver responding automatically in the Clark Wireless Telegraph System, always in readiness for the next dot and dash.

It is this automatic feature which gives the Clark Wireless Telegraph the same speed as the wire telegraph and this is one of the chief points of distinction that places the Clark Wireless Telegraph System above all other foreign systems which are not automatic, but which are mechanical in action and are limited to one third the speed of the sensitive Clark responder. The Clark receiver is superior in freedom from local disturbances and is always reliable. Only with the sensitive Clark responder has it become possible to establish long-distance wireless telegraph communication between Detroit, Mich.; Buffalo, N. Y.; Cleveland, Ohio; Toledo, Ohio, and Port Huron, Mich., when using a very small power at the transmitting end for overland work.

Demonstration.

[In the first demonstration Mr. Clark showed the operating of a small portable receiver and transmitter, the ringing of a signal bell, the automatic recording of signals on tape machine, the starting and the stopping of small motor. Each part of the apparatus was explained in detail and was passed around to the members of the society to inspect. Mr. Clark explained their respective functions in the operation of the wireless machines, etc.

A 1 kw. rotary generator was then placed in operation and was connected to the 110 volts direct current. The alternating end was connected to the transmitting transformer with the shunt circuit across the spark-gap, consisting of inductance and a plate glass condenser, the inductance forming the primary of the oscillating transformer. This particular set of instruments had been used on the steamer *Western States* during the season and had given good results to the talking distance of 180 miles, using a wave length of 425 meters.

At this point of demonstration the room was darkened and Mr. Clark proceeded to show how this wave-length was measured on wireless telegraph and how the various stations are adjusted for different wave-lengths and how the tuning is accomplished on wireless stations by changing the inductance or capacity. Mr. Clark showed on this same set of transmitting instruments the changing of capacity and inductance so that the wave-length was increased from 425 meters to 750 meters. The aërial capacity consists of No. 8 B. & S. wire made up of 7 strands No. 22. This bare aërial wire was spread out in the laboratory room to the distance of 150 ft. and radiation was plainly seen to be very powerful.

Mr. Clark explained the construction of the wave meter, consisting of sliding tube condensers arranged to be joined in series or multiple series with variable inductance coil. The coil and condenser capacity were so arranged and connected electrically together that by the simple movement of the adjustment screw variations were simultaneous, the capacity of the condenser and the turns in the induction coil being in the same proportion. With the adjustment of a dial or scale placed above the condenser capacity and inductance coil one was able to read off the wave-lengths in meters and the wave-lengths in feet, as well as the oscillating constant, — the term "oscillating constant" signifying the square root of the product of the numbers denoting the capacity of the condensers reckoned in microfarads and the inductance in centimeters.

A general debate and discussion took place. Many questions were asked relating to the tuning and interference and to the amount of secrecy that might be obtained on the station. Mr. Duffield asked whether Buffalo station and Port Huron station could work at the same time that Detroit and Cleveland were working, and so on. Mr. Clark explained that in commercial work this had been done during the past season.

Colonel Davis asked whether, when the Soo station was working, it would be possible to talk with Duluth or Buffalo and Cleveland, and whether at the time that they were talking it would interfere with other stations or whether the other stations could be talking with each other at that time. Mr. Clark explained that as Detroit station had only a 5 kw. and Toledo a 2 kw. machine, Port Huron having a 10 kw. and Buffalo a 15 kw. and Cleveland a 10 kw., all these stations were arranged for different wave-lengths, and that in transmission and in receiving,

while the Soo with a 25 kw. machine should be sending messages to Buffalo or to Duluth, the stations at Detroit and Toledo could be working right along on shorter wave-lengths and there would be no interference.

Mr. Clark showed a map of the Great Lakes showing all the various stations and the zone in which each station was working, and he showed some of the high-frequency discharge and oscillations that took place on a high-tension 10 kw. station.]

Wireless Telegraph Work in Connection with the Marine Interests on the Great Lakes during the Season of 1907.

The stations of the Clark Wireless System opened early in March for the season of 1907. There were but two stations in operation at this time, one located at Detroit, Mich., and the other at Cleveland, Ohio. Early in the month of May another station was placed in operation at Port Huron, Mich. In August a fourth station was placed in operation at Buffalo, N. Y., and in September a fifth station was placed in operation at Toledo, Ohio, making a total of five wireless telegraph stations, bringing Buffalo, N. Y.; Cleveland, Ohio; Toledo, Ohio; Detroit, Mich., and Port Huron, Mich., into wireless communication.

Detroit, as is well known, is the point on the Great Lakes at which vessel owners usually intercept their vessels with messages if the port of consignment of cargo has been changed since the vessel left the head of the lakes; and as vessels frequently leave the head of the lakes without the knowledge of their port of destination, this was communicated to them by the Clark Wireless System on passing Detroit. So efficient was the wireless service in this, that, during the season of 1907, over 23 000 vessels' orders were transmitted by the Clark Wireless service between Cleveland, Ohio; Buffalo, N. Y., and Detroit, Mich.

Port Huron, Mich., as a point of passage, is of great value to vessel owners, and it was from this station that the reports of vessel passages were flashed into Cleveland, Buffalo, Toledo and Detroit. This gave the vessel owners ample time to formulate their dock orders before the vessel reached Detroit. It usually takes four to five hours to make the passage in the river from Port Huron to Detroit. The Clark Wireless Telegraph station at Port Huron reported over 25 000 boat passages during the season of 1907.

Beginning with the opening of navigation, the Clark Wireless Telegraph Company began the work of soliciting the telegraph business of the bulk freight owners from many of the

large marine interests on the Great Lakes. These interests combined represent some 320 fleets and over 1 000 vessels. The telegraph work consisted of reporting boat passages, orders, etc., from Port Huron and Detroit to the owners' and managers' offices in Cleveland, Toledo and Buffalo, and in receiving in reply messages and orders for the captains of the boats as to the destination for the vessel to go with her cargo; also furnishing the Cleveland office with all the up-and-down passages at Port Huron station. These were transmitted twice daily. The passages up to 8.00 o'clock in the morning were sent in at 8.30 A.M., and the passages up to 1.30 in the afternoon were sent in at 2.30 P.M. The vessel owners were able to formulate the docking destination orders before the vessels reached Detroit from these reports. In many instances the vessel orders and destination orders were given for the vessel on passing at Detroit and the destination changed again before the vessel passed the Lime Kiln Crossing. In many cases this could not have been accomplished by wire telegraph or even long-distance telephone, the Cleveland station operator and Detroit station operator transmitting and delivering some of these rush message orders in less than three minutes. A total of nearly 70 000 messages was handled during the season of 1907 for marine interests by the Clark Wireless Telegraph System. Had the five stations been in operation with the opening of navigation the number of messages handled by the stations would have been more than doubled for the season. The stations were operated for the entire season without delays or serious interruption.

The stations were in charge of men who had received some training in wireless telegraph work at the company's shop. They also had had some telegraph experience with the Western Union or Postal Telegraph companies in commercial work; without this previous experience they could not have handled the work so rapidly. When we consider that with comparatively new men on some of the stations — this being their first year in wireless work — this system of stations has been able to do this large volume of telegraph business, it speaks well for the men who had charge of the wireless telegraph work.

The stations at times were extremely busy and kept the operators on the jump. The telegraph strike of the wire telegraph operators in the month of August was cause for the immediate use of the Clark Wireless System by many commercial firms outside of the marine interests, and some 2 000 large business houses located in Detroit, Cleveland, Port Huron and

Buffalo took advantage of this system of communication; also many press dispatches were handled daily. The business firms and individuals that tried the wireless service remained with the Clark Company as customers when they found that the service was much quicker and just as reliable as the wire telegraph.

During the season of navigation the stations handled many messages from the stations to boats and from the boats to the stations, for passengers on the steamship lines which carried wireless equipment. Also reporting of the passenger boats as to their docking time and reporting of the cargo to the dock foreman and superintendent from four to five hours in advance of the steamer's reaching the dock was valuable information and was the means of handling the freight on arrival of the boat more systematically and rapidly; also during certain portions of the season, both in spring and autumn, the heavy fogs usually tying up all boats on the rivers and delaying them from three to five and six hours, wireless telegraph service proved of the greatest value.

The stations were kept open for twenty-four hours' service daily, but the night work this season proved very light, few messages being sent or received after the hour of 9.00 P.M., the operators merely sitting in circuit to receive a call or warning in case of accident to any of the boats carrying wireless equipment. With only a few boats equipped this night work did not pay, but with a larger number of boats carrying wireless equipment and paying for this service, a more favorable showing could be made. An increase is looked for from this source.

As for the outlook for profit-paying business from the first year of operation with only five stations, covering but a small portion of the lower part of the Great Lakes, the revenue so far derived was very gratifying and encouraging. The gross fixed expenses per month on each station for twenty-four hours of operation, which includes salary to all operators, messengers, power, light and miscellaneous, amount to $350; on 5 and 10 kw. stations, with each station handling 150 messages daily at a rate of 25 cents each, the earning on each station would amount to $975 per month of 26 days. Giving all the five stations the full number of messages daily which they could handle with practically no increase in the operating expenses and carrying work on for the entire season, the gross earning would amount to $48 750.

With an extension of the wireless telegraph system over

all the Great Lakes territory, with say twenty stations in operation, which would greatly increase the number of calls per station, and covering a much larger territory, with a larger increase in customers to each station, the gross earning power for the twenty stations per year would be $194 000. The maintenance cost is very low as compared with maintenance of wire telegraph with poles, etc.

Over a hundred of the men who have the management of affairs for the large marine interests on the Great Lakes have been talked with, and all say, " Without question the Clark Wireless service has proven the most perfect telegraphic communication ever furnished in this country." The Clark Wireless Telegraph Company has had a hard fight to gain a foothold on the Great Lakes and the work has just commenced. Public sentiment is to-day quite favorable. The straight push ahead policy followed by the management has won the hearty and highest respect of all the men connected with the large marine interests on the Great Lakes, and hundreds of others who have used the Clark service have learned to know its value.

The engineering and scientific ends are successful. The organization of the commercial end will have to be perfected before we can hope to handle all the business that the system of stations can take care of.. We have made a good start and shall work up slowly but surely.

Wireless Telephone.

The success attained in the wireless telegraph field has long kept awake the hope of a practical realization of wireless telephone, but as long as the violent jerky spark as used in wireless telegraph was the only source, the fulfillment of the hope was not to be thought of. While the oscillating discharge was suitable and adaptable for wireless telegraph, it was not sufficient for the delicate telephonic transmission of intelligence. In wireless telephone we need a steady continuous undamped oscillation of high-frequency waves.

Prof. Elihu Thompson recorded, some ten years ago, the peculiar phenomenon that a direct current arc lamp light produces high-frequency alternating currents by shunting the arc with a circuit containing a suitable condenser and inductance, and later the properties of the singing arc were investigated by Duddell. In the shunt circuit, if we employ suitable condensers for capacities, we may be able to produce frequency from a few hundred up to hundreds of thousands of cycles per second,

whereas in a generator set for ordinary alternating current a fixed frequency only is attained. We must maintain vibrations in wireless telephone communication corresponding to the human voice, averaging five hundred per second to twenty thousand per second for the overtones.

Experimental results were obtained along this line first by Simons in wireless telephone on speaking arc experiments and later by Poulsen, the Danish electrician. From these small beginnings the wireless telephone has gradually developed into a more commercial and dependable instrument, and by a series of careful tests and arrangements we now are able to produce a continuous undamped oscillation to record all speech and sound or tones produced in the transmitter.

At present there are several methods of producing the undamped oscillation. I am now working with a multiple subdivided arc lamp, each lamp or arc occurring between cooled electrodes. The positive electrode is of copper and is fitted to a brass or copper tubing and this tubing is filled with water, the negative terminal being carbon. In forming the arc between the hollow surfaces of the copper electrodes and the carbon there is very little regulation required. The copper does not burn away and the carbon burns very slowly.

With a current of 3.5 amperes at 220 volts, or 1.5 amperes at 440 volts, a talking distance of from 5 to 15 miles can be reached.

The results so far obtained have been very satisfactory. Labor and time have been put in on this work, etc., each day, with better results always looked for, and it is quite a fine piece of work and requires careful adjustment to bring the receiver and transmitter into tune for talking. The capacity of the aërial wire at both stations requires careful adjustment and displacement in order to bring them in resonance. There is no question in my mind but that wireless telephone communication will be obtained up to one hundred miles or a longer distance in the near future.

Noticeable features are the absence of any capacity effect and that the tones of the voice are very perfect, no telephone noise being recorded.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1908, for publication in a subsequent number of the JOURNAL.]

THE WEALTH AND PROSPECTIVE DEVELOPMENT OF THE WEST COAST OF SOUTH AMERICA.

By Francis W. Blackford, Member of the Montana Society of Engineers.

[Read before the Society at its Twenty-first Annual Meeting, at Bozeman, January 11, 1908.]

This is not a technical paper, but one written at the request of President Kinney for something of interest to read to the Society at its annual meeting. I spent a little more than three years in professional work in Peru, as chief engineer of the Cerro de Pasco Mining Company; and chief engineer, and a part of the time superintendent, of the Cerro de Pasco Railway Company. I had charge of the construction of the railway from the beginning of the surveys to its completion, and the engineering work and surveying in and about the mines for over three years. During the period of my residence my time was too fully occupied to permit of much travel or the gathering of statistics, but I gained some general knowledge from observation, reading and intercourse with others that should be of interest to engineers, and possibly of profit.

Conditions in foreign countries are different from those at home, and the roseate hues which, in the imagination, surround far distant places are often dispelled by actual contact. We find that there are better opportunities overlooked at our own door. One of my clients once remarked: "I consider your services quite as valuable if you keep me out of bad things as if you put me into good ones."

The legitimate work of an engineer is the investigation of proposed undertakings, to see and weigh the bad as well as the good points and present them to his client in logical and comprehensive form. He wants facts, not theories, and conclusions drawn from facts. It has been my aim in this paper to point out some of the features and difficulties of work in a foreign country which were brought out prominently by my experience.

At the time of the Spanish conquest most of the west coast of South America was called *Peru*. The civilization found there was that of the *Incas*, which was similar to that of the Aztecs in the valley of Mexico, these two having the highest order of

civilization found on the western continent. The monarchy was absolute, and the ruler was called the "Inca." His country extended from somewhere north of Quito, now in Ecuador, to a point in what is now Bolivia. There were two capitals: Quito in the north, and Cuzco in the south. Following the conquest, stories were prevalent throughout western Europe of the great riches of Peru. Its name was a synonym of wealth, and the halo of romance that surrounded it has remained, in a measure, to the present day.

The story of the room full of gold as a ransom for the life of Atahualpa, the last Inca, and the subsequent yield of the mines of gold and silver worked by the conquerors, is doubtless responsible for the exaggerated idea of the wealth of the country. The gold to fill the room up to the height of the head of the conqueror — six feet one (as evidenced by the well-preserved remains of Francisco Pizarro, now in a glass case in the cathedral in Lima) — was gathered from all parts of the country, and it was only after much time and considerable difficulty that the subjects of the Inca were able to collect the amount imposed by the conqueror. With commendable generosity he permitted them to pile the gold ornaments at random in the room, not requiring them to be placed so as to occupy the least space.

After the room was full to the point stipulated for the ransom, Pizarro killed the Inca, or caused him to be killed. This act showed to the world the character of the early Spanish explorers and conquerors. They ruthlessly murdered those who resisted, and made slaves of the remainder.

Peru is not a rich country, never has been, and probably never will be. Wealth comes from natural resources developed by intelligent labor. Peru has neither of these, and the same may be said of nearly all of the west coast of South America, from Panama to Cape Horn.

From a point near the south boundary of Ecuador to Valparaiso, 33° south latitude, a distance of about 2 300 miles, the parts bordering on the sea are absolutely barren; it never rains there. Crops are grown by irrigation, but only in the valleys of the streams which come down from the mountains. These streams are not large because the summit of the mountains is seldom more than 60 miles from the coast. The rainfall west of the summit which feeds these streams is often torrential and destructive during the wet season, at altitudes above 6 000 ft., but those are not conditions favorable to irrigation, and as the valleys are narrow, the agricultural products are not great.

There is practically no timber, not even enough to furnish fuel for domestic use, anywhere between the coast line and a point about 100 miles east of the summit of the mountains. Within this area there is copper, silver, gold and some coal, but with the exception of the mines of silver and copper at Cerro de Pasco, there are none of great magnitude in Peru. The mountains are extremely rough and broken and reach such great altitude that prospecting is difficult, and even when mineral is discovered, it must be very rich to justify the time and money necessary either to transport or to work it. The passes in the Andes in all of this district have from 10 000 to 17 000 ft. altitude, and most of them exceed 13 000 ft.

There is some coal in the country. I examined with considerable care two fields, one on the east side of the range and one on the west side. There were many croppings with a considerable showing in places, but the strata were so twisted and faulted that I found it impossible to trace the veins for any distance, and failed to find any body of coal that appeared to be continuous or gave promise of profitable returns to a commercial enterprise.

There were practically no highways in the country, only trails, and those mostly bad and selected without much regard for rise and fall. The best trail I saw was an old Inca trail, probably a part of the great road from Quito to Cuzco, described by Prescott (description copied by me into a paper on "Highways and Street Pavement," read before this Society in 1898). I think Peru has no laws for the construction and maintenance of highways; if it has, they are not enforced and the trails are in a frightful condition.

The transportation problem is a serious impediment to the development of any part of this section of country. Except the two railways hereafter mentioned there are no means of communication other than pack trails; therefore the development of any mines or agricultural district requires the time and money necessary to construct wagon roads or railways. The mines at Cerro de Pasco had been worked for two hundred and fifty years and are said to have produced more than 1 000 000 000 oz. of silver, yet there was never anything but a pack trail from there to Lima, a distance of nearly 200 miles. After the completion of the Oroya Railway, in 1894, a wagon road was constructed a part of the way to Oroya, its terminus, and a pack trail the remainder. This was done by private subscription among the mine owners. This was followed by the construction of the Cerro de Pasco Railway from Oroya to Cerro de Pasco in 1903–4, and short branches aggregating 112 miles.

Another feature very important is the transportation of skilled labor. Such labor has to be paid its time and expenses from the place where it is hired. To reach there from North America or Europe takes about a month. Count this twice, and allow two weeks for acclimating, and you have lost a little over 10 per cent. of the time of any employee engaged for a two-year period. There is also more or less going back and forth by the higher salaried men, with the attending expense and loss of time. The manager of one of the Peruvian enterprises very aptly remarked that "one might think this an enterprise for the promotion of foreign travel."

The wages for skilled labor are high. Unless you pay more than the man gets at home he will not go. Many that go are unsatisfactory or incompetent, or become dissatisfied and leave. The supply, in consequence, is likely to be short, the discipline less exacting and the services less efficient and productive. The expense and annoyance from this source are very great.

Common labor in Peru is cheap and fairly good, but scarce. The number of persons who gain a livelihood by this means is small. For our work, the enganching process was used. For a consideration of ten cents for each day's labor, paid to a local officer, priest or prominent citizen, he would gather together laborers from the little farms or large ranches and engage them for from two to six weeks' service. This labor often came long distances, as much as 100 miles. The system is more or less feudal. The laborers usually came unwillingly and left as soon as their time was up, but it was the only way to get them; except at the instance and under the direction of those named, they would not come at all, nor could we ever get this class of labor either at planting or harvest time. They live at out-of-the-way places in a very primitive fashion, and produce practically all they need. We paid for common labor one Peruvian *sol* per day, equivalent to 48.5 cents United States money, and 10 cents, Peruvian, to the *enganchador*. At Cerro de Pasco and round about there were regular miners, laborers and packers, but only sufficient for the work going on there.

I had, at one time, a commission from the President of Peru to make a reconnoissance for a railway from Oroya, or from a point between there and Cerro de Pasco, to a point at or near the head of navigation for steamboats on the Amazon, or its tributaries, these reconnoissances to be followed by surveys. In pursuance of that plan instruments and equipment for two locating parties were purchased. When I was ready to start,

however, the funds to defray the expenses were not available, and several months afterward, when they were, my duties with the Cerro de Pasco were such that I could not go, and later on, owing to political changes, the project, much to my disappointment, was abandoned.

In the meantime, however, I had gathered all available information about the geography, topography, products, etc., of the country, and was surprised to find how little was known. Various travelers, including priests, rubber hunters, prospectors and others, had seen each a part of the country, but the knowledge thus obtained was not classified and really was of little value. Small steamboats in the rubber trade ply the river and its tributaries above Iquitos, which is the head of navigation on the Amazon for ocean steamers. Those engaged in that trade say the valleys are fertile and not unhealthy and that the forests in some districts are infested by cannibals who use poisoned arrows. It is not likely, therefore, that they went far from the river, or explored to any great extent the tributaries where the natives were bad.

The river valleys in these sections are covered with a dense forest. According to reports received, the rivers were navigable to about an altitude of 2 500 ft., but there was very little information in the possession of the government as to where the head of navigation actually is or the most practical way to get to it. I believe from reports that the forests begin in some sections at about 6 000 ft. altitude and continue eastward; that they are dense tropical forests containing more or less timber of commercial value, but nobody with whom I talked had very exact knowledge. One of the engineers of the Cerro de Pasco Company made a reconnoissance of the mountainous district east of the main range for two or three hundred miles north of Cerro de Pasco. He said that the country was terribly rough and broken, sparsely inhabited and barren; that at times he could not get fuel to cook his food. He described the country as similar to that which I had seen 40 to 50 miles north of Cerro de Pasco.

This was built on stupendous proportions and was of incredible roughness. It afforded, however, a view of grandeur and magnificence seldom seen. The peaks of the main range have an altitude of more than 20 000 ft. and the sides are covered with glaciers of great thickness, — judging from appearances lower down I should say at least 1 000 ft. I crossed the range at two passes to the south of these high peaks and boiled water to get the altitude. None of our aneroids was reliable above 13 000

ft., and many of them would not work at all, notwithstanding they were rated for 20 000 ft. These passes were about 16 500 ft. A short distance above them the glaciers began; in fact, I went up to a glacier and broke off a piece of ice to melt for the boiling water. From this altitude the glaciers were not continuous, but lay in patches not confined to ravines, but plastered in places to the sides of the almost vertical slopes in a most unaccountable manner and looking as if they might slide off at any moment. Much to my regret I never had time to visit any of the great ice fields, or the termini of the great glaciers which came down from the high peaks. At that latitude, 12° south, on the main range they begin at about 16 000, and at from 17 000 to 18 000 pretty well cover the mountains and continue to the top, excepting on exposed spots, where the wind blows the snow away. On a secondary range of peaks, lying about 75 miles to the east of the main range, the line seemed to be lower, and doubtless was, but I never was able to go over there to investigate. From the higher points near Cerro de Pasco on a clear day those glittering monsters were very impressive, grand, solemn, silent and untrod. The eastern peaks, though lower than those of the main range, were seldom seen, being enveloped in clouds except in the clearest weather. The altitude of Cerro de Pasco is 14 200 ft. A thermometer in the shade there would range from about 16 to 60 degrees fahr. in 24 hours.

From my observation, and information received from other sources, I should say that in all that stretch of country from Ecuador nearly to Santiago, Chili, there are only a few comparatively smooth spots, one being near Cuzco, another near Cerro de Pasco, another near Quito. All the remainder is a mountainous country, extremely rough and broken, semi-barren, and much of it high and covered with glaciers. On the west side, from a short distance below the summit to the sea, it is without trees or grass, and practically without rain. From the summit of the mountains eastward about 100 miles it is likewise very rough and broken and practically without timber, but bountifully supplied with rain during the rainy season, a fair grazing country, and susceptible of agriculture in a small way, sufficient to supply the needs of the native population. Beyond this point, and below about 6 000 ft. altitude, the country is tropical and covered with forests; at about 2 500 ft. the rivers are navigable for small boats. Away from the rivers little is known of the country in the lower altitudes.

Under such conditions, how can the west part of South

American develop into a rich or productive country, or develop rapidly?

The Pan-American Railway in these parts is a dream of dreamers that doubtless will never be realized. The country in the river valleys east of the mountains, if it is rich and habitable, would get an outlet and a market for its products eastward and northward on the lines of drainage. Such natural barriers have always separated nations and diverted trade. Transportation enterprises are not seeking lines involving summits of 16 000 ft.

The Oroya Railway is ocular proof of the difficulties of such obstacles. It has been described so often that I shall say no more here than that it starts from Callao, the seaport 7 miles from Lima, and stops at Oroya on the east side of the Andes, at an altitude of 12 400 ft., and has a total length of 130 miles. It crosses the summit at Galera tunnel, where the grade line has an altitude of 15 665 ft. The gradient is supposed to be 4 per cent., but in places it is now 4.5. It is standard gage and has 16° maximum curves. It follows up the valley of the river Rimac, and overcomes the altitude by 11 switchbacks and many turns in the Rimac valley or its tributaries, these turns involving tunnels or heavy cutting and filling. The line is on the mountain side most of the way and shows very clever engineering, some of the greatest of its kind in the world. There are some 58 tunnels and many high and expensive bridges. Four engineers prominent in the West, and some of them well known in Butte, *viz.*, Messrs. Bogue, Briggs, Maxwell and McCartney, spent several years on this work. During the seventies, Henry Meigs, a Californian, promoted such improvements in Peru, using the credit of the government, and obtained about £12 000 000 sterling. This was all spent, most of it in railway construction, the result being two unfinished standard gage railways part of the way across the mountains, one terminating at the Port of Mollendo, the other at Callao, as aforesaid. The Oroya Railway runs two passenger trains each way a week, and as many freight trains as are necessary to do the business. When I went there in 1901 it was one a day, consisting of three cars, or about 50 tons net maximum load, taking two days to come up. This business, however, was greatly increased later, hauling the construction materials and supplies for the Cerro de Pasco Company, at $15.00 United States currency per ton.

The road is subjected to serious landslides which interrupt traffic for weeks at a time. Prior to 1901 it had never paid more than operating expenses and much of the time not that. Of the

Mollendo road I know but little. Its financial condition is much the same as the Oroya Railway, but its cost was less.

Of the Peruvians, the descendants of the Incas, as well as the Mexicans, the descendants of the Aztecs, either of pure blood or mixed with Spanish or other blood, I wish to say that I consider them equal in natural intelligence to any people on the earth. Their opportunities have been limited and they have had training only in a few lines, but they are good workers, with keen natural intelligence that responds to instruction as quickly and effectually as any I have ever seen. In the art of cutting and laying stone, carpentry, building in general, blacksmithing, mining, packing and driving animals, and such arts as they have been trained to, they show great skill. I would put the native Cerro de Pasca (Peruvian) or the native Guanajuato (Mexican) miner against the best that Butte could produce and expect to get as good results (and at the present time, at about one seventh the cost).

The people of Peru are naturally as intelligent as those of other parts of the earth, but they are lacking in training, especially in the mechanical arts. They do not know how to do things, therefore their labor does not produce much wealth. Class distinctions are closely drawn; we have the man who works with his hands and the man who does not, and the man who does not has but little knowledge to direct the man who does. There are, of course, exceptions to these generalities, but they are in the main true.

Very little attention is paid to the details of agriculture or stock raising. The vegetables and fruits are all run down and the yield is small. The males of all domestic animals are permitted to run without selection with the flocks or herds and, as a consequence, the stock is run down; fowl, the same. There are no fruits except some tropical varieties; notwithstanding there is variety enough in the climate, due to difference in altitude, to produce apples, peaches and other temperate zone fruits. Very little attention is paid to the art of cooking, and as the material is bad and variety limited, the food is bad — the worst I have ever eaten.

The Chileños are more progressive than the Peruvians, and, indeed, more progressive than any people south of Mexico — probably south of the United States. They have paid more attention to education, have established agricultural schools and experiment stations, and have encouraged the mining of copper nitrate and coal. The mining is carried on mostly by foreigners.

Southward from a point a few hundred miles north of Valparaiso there is some rain on the west coast. This gradually increases and becomes very heavy to the southward, but the country around Valparaiso and between there and Santiago is semi-arid and agriculture is carried on only by irrigation in the valleys. The stock is good and the fruits and vegetables compare very favorably with those of the United States and are distinctly temperate zone products.

There are a number of railways of standard gage in fair condition. One railway is projected to connect with the Argentine system. The termini of the lines were about 25 miles apart when I crossed over in January, 1905, and construction work was going on slowly on the Chilean side. The plan contemplates a long tunnel. The altitude of the pass is a little over 13 000 ft. I could not learn much about the plans, but should judge from the topography that a 2-mile tunnel would not reduce the summit altitude more than 1 000 ft.

The main railway system in Chili has a standard gage, that of Argentine a 6-ft. gage. The connecting link, which is some 200 miles in length, is a meter gage. The maximum grade seemed to be about 3 per cent., except where there was a rack and cog. There it was anything between that and 10 per cent. There was a rack fastened to the ties in the center and extending 3 or 4 in. above the rail, and a cog on the driving wheel. The engagement was made very readily without stopping, and the system seemed to work well. Transcontinental freight will have to change bulk twice by this route.

When I made the trip from Valparaiso to Buenos Aires, it was as follows: 5 hr. by standard gage, 5 hr. by meter gage, stop at an inn 8 hr., diligence with 4 horses abreast 6 hr., saddle mule 3 hr., meter gage railway 7 hr., then 6-ft.gage express train (sleeping and dining-cars) 24 hr.

But to get back to my subject on the west side of the mountains and conclude:

I should say that Chili has more agricultural and mineral wealth than Peru, but the whole west coast of South America, as compared with the fertile and otherwise richly endowed spots on the earth, such as Europe, China, India and the United States, is of very little importance in the world's commerce and affairs and does not offer quick or profitable returns for large enterprises.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1908, for publication in a subsequent number of the JOURNAL.]

THE RIGHT-OF-WAY OF THE GREAT LAKES.

By F. C. Shenehon, Member of the Detroit Engineering Society.

[Read before the Society, January 16, 1908.]

Mr. President, Gentlemen: Any device for transporting passengers, commodities or freight has, of necessity, two essential correlative parts, — the carrier and the track. In the case of a water route, the tracks may be infinite in number, and the locus of these tracks may be called, for lack of a better term, the *right-of-way*, after the analogy of a railroad. The Great Lakes, viewed as the right-of-way of a transportation system, is my subject to-night.

There are a great many structures on the Lakes, magnificent ship locks, canals and canalized rivers, splendid breakwaters and harbors, docks and terminal devices for the rapid handling of cargoes. The right-of-way is planted with lights and buoys to guide the vessels, and the vessels themselves and the commerce of the Lakes are worthy of many papers. It is hoped the discussion will develop some things concerning these, but in *this* paper it is purposed to deal with the naked right-of-way of the Great Lakes — the basin, the water, the property and its engineering administration — and to touch on some of its problems.

The total water area of the Great Lakes is 95 645 square miles, and this includes the interlake rivers and the St. Lawrence River so far as it marks the international boundary. Lake Superior, with its 32 060 square miles of surface, is a third of the whole; Michigan takes 23.3 per cent., Huron 24.3 per cent., Erie 11.1, and Ontario 7.8 per cent.

Nearly two thirds of this area, or about 62 000 square miles — which is roundly the area of the New England states — lies on the American side of the boundary.

The vitality of the Lakes comes from a watershed of 192 600 square miles; the whole drainage area — that is, watershed plus water surface — is 288 245 square miles. The surplusage of water which flows down the St. Lawrence River and ultimately debouches into the ocean is over 250 000 cu. ft. per second.

The mean surface of Lake Superior is 602.31 ft. above the level of mean tidewater in New York harbor. In St. Marys River a descent of 21 ft. is made, about 19 ft. of this being in

the rapids at Sault Ste. Marie. This brings us to Lake Huron. Out of this Lake Michigan opens through the level roadway of the Straits of Mackinac, and because these lakes are simply two lobes of one level body of water connected with a bypass, it is not uncommon to speak of them as a unit hydraulically —Lake Michigan-Huron.

From Lake Huron down to Lake Erie is two steps, one of $5\frac{3}{4}$ ft. in St. Clair River to Lake St. Clair, and a second of 3 ft. in the Detroit River to Lake Erie — still 572.60 ft. above the sea.

From Lake Erie to Lake Ontario the descent in the Niagara River is 326.42 ft., and 160 ft. is sheer fall over the Cataract.

The St. Lawrence River, during the 110 miles of its course as a boundary stream, makes a descent of 94 ft. from the level of Lake Ontario.

Summing up the several steps from Lake Superior down to St. Regis shows a total descent of 450 ft., with the river still 152 feet above the Atlantic Ocean.

Lake Superior has an axial length of 382 miles, with a maximum width of 160 miles, and depths as great as 1 000 ft.; Michigan is 345 miles long by 118 miles wide, with 870 ft. maximum depth; Huron, 265 miles long by 146 miles wide, with 750 ft. maximum depth; Erie, 250 miles long by 57 miles wide, with 210 ft. maximum depth; Ontario, 202 miles long by 53 miles wide, with 738 ft. maximum depth.

Now these great fresh-water basins differ from artificial reservoirs mainly in their splendid scale. Despite their bigness they are simply reservoirs, and to a considerable extent at the present time they are artificial reservoirs; that is, the natural surface levels have been changed — raised or lowered — by engineering works in the outflow rivers, or by the creation of artificial independent outlets. And these interferences with the surface levels exist on each of the lakes, and, except in the case of the Lake Superior compensating works, they were not intended to produce the effect which has come from them.

It is expected to show later that engineering works specifically designed to control the outflow and fix the lake surface levels at desirable stages must eventually supersede the present mongrel condition. By *mongrel* I mean neither purely natural nor purely artificial.

Well, each lake is impounded, and its level fixed, primarily by a natural barrier in the outlet. For Lake Superior, ledge rock — Potsdam sandstone — forms a dam, a submerged weir in St. Marys River. At the crest of the weir, which is at the head

of the rapids, the water runs crystalline clear over the clean ledge rock. I speak of this crystalline quality of the water not for picturesque effect, but because this very clearness of the swift water is an element in the permanence of the dam. The lake above is a settling basin, so the water rarely carries any sediment, and the dam is saved the fierce and incessant bombardment of minute particles characteristic of sedimentary streams. The downstream slope of this natural dam is rock in place strewn with glacial drift, forming the bed of the rapids — with a descent of 19 to 20 ft. in $\frac{3}{4}$ of a mile. The rapids at the "Soo" have the effect of a sheer fall, and backwater from Lake Huron has no retarding influence on the outflow of Lake Superior.

Lake Michigan-Huron is held primarily in check by a constricted outflow section at Port Huron, a *gut* over 60 ft. deep by 700 ft. wide, and this is reinforced by the inertia of the St. Clair and Detroit rivers. The hydraulic conditions existing in this wasteway are somewhat complicated. Considering each of the lake outflows, however elongated, as a submerged weir, the St. Clair-Detroit River weir has a downstream slope length of 85 miles. In spite of this great length, the efficiency of flow is affected by the tail water. That is, backwater from a high stage of Lake Erie at Amherstburg retards the outflow of Lake Huron at Port Huron. It is not difficult to credit this, because the fall between lakes is only $8\frac{3}{4}$ ft. That $8\frac{3}{4}$ ft. is the potential needed to maintain a certain volume of flow. Should Lake Erie rise 3 ft., only $5\frac{3}{4}$ ft. remains, and that $5\frac{3}{4}$ ft. of fall could hardly be expected to do the work accomplished by $8\frac{3}{4}$ ft. before.

Lake Erie is impounded primarily by a limestone bed rock ledge or submerged weir at Buffalo, but, as in the case of the St. Clair River, this is dependent for its efficiency on the inertia, resistance or backwater in the river below, reaching here for 20 miles to the rapids above the Cataract at Niagara Falls. The ledge rock at the head of these lower rapids, forming a second submerged weir, reinforces, by backwater effect, the initial submerged weir at the head of the river. As the river descent between these two weirs is but ten feet it is easy to understand the correlation of the weirs.

Lake Ontario finds the barrier which restrains it at the Galop Rapids, 67 miles down the St. Lawrence River, where a submerged weir of sandstone exists. From the point of view of hydraulics this 67 miles of placid river flowing leisurely through the Thousand Islands must be considered as an arm of the lake, even though in this reach a descent of two feet is made.

The Galop Rapids has a fall of eight feet in one mile, and the weir discharge is not affected by backwater in the lower river.

I have explained the construction of the waterways of the basins of the Lakes in some detail because the integrity and the betterment of the right-of-way hinges on them.

Now it has been estimated that if Chicago should be given 14 000 cu. ft. of water per second which she wants for the Drainage Canal, Lake Michigan-Huron, Lake Erie and Lake Ontario, and all the rivers from St. Marys below the locks, down into the St. Lawrence, would drop somewhere in the neighborhood of eight or nine inches. This eight or nine inches means much or little only as it scales on the measuring stick of dollars, and this leads to a brief discussion of the commercial use of these reservoirs and connecting rivers, which form the right-of-way of the Great Lakes.

You will remember that La Salle in 1679 built the *Griffon*, the first ship to sail Lake Erie, and that it shortly vanished into thin air. A part of the navigators of those days were missionaries interested in saving redskins; but some of them were more interested in saving beaver skins, and most of them had their hands full at times saving their own skins. These voyageurs, missionaries and fur traders, with their canoes and bateaux, had little thought of *aids to navigation*, yet at Sault Ste. Marie, on the Canadian side, just 110 years ago, they were building a lock to facilitate the climb of the rapids, and in 1850 a tramway portage was built on the American side. The authorized charge on this tramway for getting freight past the rapids was 5 cents a hundred pounds, or $100 per ton. While this charge as a mile-ton rate is more than 1 000 times that of average Lake freights rates at the present time, it was not for this reason solely, nor the delay, but because, in addition, vessels were needed on Lake Superior, that a ship lock was wanted at Sault Ste. Marie. The agitation for a ship lock preceded 1840, in an attempt to get from Congress a land grant to enable the state to build a lock. This land grant was secured in 1852, and the ship lock was completed in 1855, with chambers 70 by 350 ft.; the canal draft was fixed by the terms of the land grant at 12 feet.

The principle that the general government had any *right* to expend money on streams subject to interstate commerce was not entirely accepted even in 1855; but in 1856, under the somewhat facetiously accepted doctrine that the improvement of these channels would assist a naval movement, and could therefore be construed as a war measure, appropriations to secure 12-ft.

draft in St. Marys River were passed over President Pierce's veto. The opening of the lock at the "Soo," and this dredge work in St. Marys River, and that in St. Clair Flats, gave nominal 12-ft. navigation between Duluth, Chicago and Buffalo; and this dredge work in particular marks the full assumption by the general government of the burden of improving, maintaining and operating the right-of-way of the Lakes as an interstate highway. State sovereignty was more keenly felt in those days, when men who had known actual state independence were still alive; and it was only a few years before the Rebellion, a war in which *state rights* was the issue.

I am not sure that the relative activities and jurisdictions of the states and the nation in the waters of the Great Lakes are entirely clear. The general principle, however, as I understand it, is this. In Lake Huron, for instance, the state of Michigan extends out to the international boundary; the state holds the title to the submerged lands in fee; the nation, on the other hand, holds jurisdiction over these waters, from the meander line out, for purposes of navigation, and as a boundary stream or lake. The exact demarcation of the respective rights growing out of these overlapping jurisdictions is not always obvious. As an instance, at Niagara Falls a certain power company has claimed the right to divert water from the Niagara River under a New York state permit; and it has been argued likewise that the state of Illinois has the right to divert the water of Lake Michigan. The government, however, reserves the right of interference with the navigable integrity of interstate waters or of waters defining the national boundary, and this reservation has even a broader international signification.

An inland lake or river contained wholly in one state, with no navigable connection leading to a second state, is not an interstate waterway; and in such a case the general government has no jurisdiction whatever. Even federal laws regarding steamboat inspection do not apply.

It is not purposed to follow the history of the development of the artificial channels, or of the harbors of the Lake system. The locks at Sault Ste. Marie have, since 1855, set the drafts and limited the vessel dimensions. The steps are these: 1855, Old State Lock, 10-ft. drafts; 1881, Weitzel Lock, 14½-ft. drafts; 1896, Poe Lock, 20-ft.; some time in the next five years, Davis Lock, 24½ ft., or greater, drafts.

You will observe that the old state lock, which was built for 12-ft. navigation, shows only 10 ft. of draft in this series. If it

had been in existence during the past season it would have had little over 10 ft. on its lower sill, and this is because the Lakes were higher half a century ago.

Even prior to this state lock of 1855 vessels of 500 tons navigated precariously on 12-ft. drafts as far as the "Soo," and 12 ft. was available in some harbors; but when the lock was once built, that became the standard, channels and harbors worked to the lock draft, and vessels were built to fit these channels and harbors.

Later, the Weitzel Lock, built in 1881, for $14\frac{1}{2}$ ft. drafts, set harbor and channel depths; and in 1896, the Poe Lock, with 20 ft., became the standard for the channels connecting Duluth, Chicago and Buffalo, and this is in operation now, but with drafts little better than 19 feet.

Our President can speak with authority of the splendid works at the "Soo," and of the canalization of St. Marys River, and that of the St. Clair River as well; and Mr. Dixon with authority on the lower Detroit River, and Colonel Davis on both. These are the critical places in the navigation of the Lakes. For the most part artificial channels are at least 300 ft. wide, with greater width on curves. In rock cuttings, and where exposed to a seaway, they have at least a foot greater depth than elsewhere. Alternating channels, one for up-bound and one for down-bound boats, are replacing single constricted channels at the Neebish, at the Flats and in the Detroit River. The danger of blocking single channels by collisions has become too great and too costly, as a day's navigation of the Lakes is worth a quarter of a million of dollars in freight charges.

Taking the Detroit River traffic as $84\frac{1}{2}$ per cent. of the Lake tonnage, the blockading of the lower Detroit River, by sinking a vessel across the channel, would entail a loss of $200 000 a day, in addition to the loss to the damaged vessels. The alternating channel diminishes this great risk.

The commerce passing the "Soo" Locks, that up to the breaking out of the Civil War had shown a maximum of 153 721 net tons, has now, in 1907, grown to the great aggregate of 58 million tons, 377 times the volume of the ante-bellum commerce.

Estimating, by the ratio of 1906, between the traffic passing the "Soo" Locks and the total traffic, shows the domestic Lake commerce of 1907 to be 85 million net tons, having a valuation of 883 million dollars. The freight charges on this at 66 cents per ton amount to 56 million dollars.

Now, if the ore and coal and grain and lumber and other com-

modities transported on this right-of-way had been moved by rail, it would have cost not less than three times as much, and the saving in freight charges is, therefore, 112 million dollars for the year; and, as a penny *saved* is a penny *earned*, this 112 millions is the earning, the dividend, distributed to the people of the nation as stockholders in this coöperative transportation system.

At the present time our railroads are inadequate to the needs of shippers, even without the additional burden of the vast freight volume of the Lakes. James J. Hill is quoted as saying that in the past few years mileage of track has increased 22.7 per cent., and traffic 126.4 per cent. If the Lake Superior ores depended on rail shipment it is doubtful if the nation's supremacy in the world's steel industry would exist. You will remember in the cases in which Judge Landis inflicted the 29 million dollar fine, the published freight rate on oil was 18 cents, while the Standard Oil Company paid 6 cents. The advantage of the octopus of a freight rate of *one third the going rate* is the same advantage our steel industries enjoy — compared with their condition without the right-of-way of the Great Lakes.

Now this right-of-way, regarded as a *property*, has a certain value, and it will be of some service to approximate this, because on property worth a hundred dollars an acre you might be warranted in making certain expenditures for surveys or improvements not warranted on property worth one dollar an acre. If the government did not own the Lakes, and could not use them otherwise than by purchase, how much would it be warranted in paying for them? The government can borrow money at 2 per cent. Capitalizing the earning capacity of 112 millions at this rate shows a present value of 5 600 million dollars for the right-of-way. And the profits on this purchase price would come in with a ten per cent. annual increase of valuation, in the fisheries, in water powers and in such subsidiary uses as for parks, reservations, and for sanitation, as at Chicago.

There are about 40 million acres on our side of the boundary, and each acre is, therefore, worth $140, — which is more than the value of farm land in Michigan. As the United States government up to the present time has invested less than 100 million dollars in improvements on the Great Lakes, the total expenditure per acre is less than $2.50; and the present yearly earning capacity is about $2.80 an acre; so the *yearly earning* is in excess of the *total investment* in improvements. The surplus earnings of three or four years of the Great Lakes transportation system will pay

for the Panama Canal. It may be of interest to add that private and corporate interests are credited with a holding of about $150 000 000 in vessels and terminal facilities.

A right-of-way of such importance, such extent and such value, is worthy of a competent engineering organization to explore, improve, maintain and operate it. You are aware that all public works relating to navigation, including the Panama Canal, are in the hands of the Corps of Engineers of the army, under the big War Secretary Taft. I am not certain, however, that every one is familiar with the genesis of an Engineer Officer of the Corps. They are all West Pointers, and the top men of each class; sometimes the four top men; this year the nine top men. The second-best men may go into the artillery, the next into the cavalry, and the bulk into the infantry. The Engineer Officers are, therefore, picked men. After leaving the academy they take a couple of years in post-graduate work in engineering before entering active service. The Chief of Engineers has his headquarters at Washington, and is appointed by the President from among the ranking colonels.

For administrative purposes the Lakes are divided into seven geographical districts, each with an officer of the Corps of Engineers at its head, and these officers, as I have said, have charge of all river and harbor improvements and of the operations of all locks and canals.

Beginning at the east end, the first district, under Colonel Fisk, of Buffalo, includes the St. Lawrence River; all Lake Ontario harbors, including Charlotte and Oswego; Niagara River; and, on Lake Erie, Buffalo, Dunkirk and Erie harbors. The second district, under Colonel Townsend, of Cleveland, takes in all Lake Erie harbors west of Erie, including the important harbors at Conneaut, Ashtabula, Cleveland, Sandusky and Toledo. The third district, under Colonel Davis, of Detroit, includes the Detroit, St. Clair and St. Marys rivers, Lake St. Clair, and all Lake Huron harbors, including Cheboygan in the Straits of Mackinac. The big works at the "Soo" and the channels in Hay Lake and at the Neebish and in the lower Detroit River, make this district a heavy one. The fourth district, temporarily under Major Keller, with headquarters at Grand Rapids, has jurisdiction over the rivers and harbors on the east shore of Lake Michigan from Michigan City up. The fifth district, under Colonel Bixby, of Chicago, includes the important works in the south end of Lake Michigan and some of the rivers and canals extending inland. The sixth district, under Major Judson, of

Milwaukee, contains the rivers, harbors and canals on the west shore of Lake Michigan from Waukegan northward; and the seventh district, under Major Fitch, of Duluth, takes in all the rivers and harbors of Lake Superior.

Now these seven engineer districts are engaged mainly in work relating to artificial channels and terminals, — that is, to *rivers and harbors.* Outside of the rivers and harbors are the open lake areas, the big right-of-way of the Lakes, with its intricate mesh of vessel tracks. In these the United States Lake Survey works. It is the engineering staff-at-large, dealing with the lakes as a unit, as a single transportation system. While the District Engineer is concerned with the needs of his own district — and there is enough work in each district to keep an officer busy — the Lake Survey handles the large questions of Lake levels with a view to their regulation, all extended surveys, soundings and sweepings, all magnetic surveys for compass variations, all charting of the lakes, and systematic notices to mariners of changes affecting navigation, — in short, the things that concern the Lakes as a whole and are vital in the operation of this great transportation system. The jurisdiction of the Lake Survey corresponds to that of an eighth district extending over the whole Lake region, overlapping, embracing and coördinating with the seven other districts, and reaching into every river and harbor. But it has nothing to do with dredge work, it does not build locks or breakwaters. The Lake Survey is under Major Charles Keller, of the Corps of Engineers.

The officers of the Corps correspond to Chief Engineers in civil practice, and they are aided by civilians — in the highest rank called Assistant Engineers, with the prefix Principal for the ranking Assistant.

The government service is attractive on account of the magnitude of the works and problems. The work is larger than two by four.

Among the public works of the United States the Panama Canal ranks first in importance, New York Harbor second, and Detroit third. Our president is Principal Assistant Engineer of the Detroit office, and Mr. Dixon is in local charge of the six-million-dollar Detroit River improvements in the vicinity of Amherstburg.

The Lake Survey also has some big problems that are attractive. Of course the Lake Survey, because it covers seven engineer districts, ought to be more important than Panama, New York or Detroit, but I cannot convince some people that

this is so. However, it is important enough to warrant my saying something about it.

The Lake Survey began work in 1841, and, except for suspended animation for a single year, has existed ever since. A part of the time it has barely existed. It is rather remarkable that the concentration of energy and the straining of resources to meet the crisis of the War of the Rebellion did not interfere with the prosecution of the Lake Survey. On April 12, 1861, Fort Sumter was fired on. In the preceding March the Lake Survey appropriation was $75 000. The succeeding years show appropriations as follows:

1862	$105 000
1863	106 879
1864	100 000
1865	125 000

It may be that the surveys of the frontier had a military significance, growing out of the possibility of international complications.

In 1866, after the war was over, and the nation felt poor, the appropriation dropped to $50 000, but by 1868 it had grown to $152 500, and remained at a good figure until the winding up of surveys in the late seventies. Then the Survey slept on a trifling annuity of two or three thousand a year until 1889, when a mild eye-opener of $7 000 was received. By 1893, with the Poe Lock building at the "Soo," and deeper-draft navigation in sight, a $27 000 appropriation was made; by 1898 this was $28 000, and in 1900 it had grown to $78 000. From that on the renaissance has been in flower, with appropriations reaching as high as $150-000 a year. The present project contemplates an expenditure of $125 000 a year for twelve years — a million and a half in all.

The reason for the rebirth of the Lake Survey is the tremendous development of Lake commerce. This has been accompanied by an increase of drafts, — with 24½ feet or more to be available in the new "Soo" lock five years from now. The present importance of the Lake vessels requires closer surveys and developments to greater depths, and submarine searches by modern sweeping methods instead of the lead-line work of our ancestors. And the hydraulic questions having to do with the preserving of the Lake levels have become correspondingly important. The Lake Survey issues navigators' charts of the Lakes, 119 different ones in all. The artistic excellence of these charts is largely due to Assistant Engineer Edward Molitor.

The information service of the Survey is an important branch. We issue a yearly bulletin full of everything pertaining to the Lakes that might be of use or interest to navigators. We issue monthly magazine supplements, and issue to the press all over the Lakes special notices of new discoveries of shoals, wrecks, derelicts, new harbor depths, new channels, dangers and aids. For survey work we have five steamers and employ, when running full tilt, from 150 to 200 men.*

The geodetic work of the old Lake Survey is a classic and that of the new Lake Survey is a second volume, but to my mind the hydraulic work of late years, having in view the betterment of draft conditions by artificial control of the efflux, has a fuller interest.

It has been estimated that a change of a foot of draft in one of the large Lake carriers will make a load change of ten per cent. of her 19-ft. draft cargo-carrying capacity. That is, a vessel carrying 10 000 tons of ore on 19-ft. draft will carry 11 000 tons on 20-ft. draft, and 9 000 on 18-ft. draft, while the operating expenses will change very little between 18-ft. and 20-ft. drafts. Were all the vessels of the Lakes loaded down to 20 ft. instead of 19, the cargo, which now costs 56 millions to move, would be moved with a saving of four or five million dollars a year.

It is because every inch on the big carriers means fifty to eighty tons of cargo that owners load to the limit. In the "Soo" locks the government had to build breast walls to keep vessels off the miter sills and had to measure up their draft to prevent grounding and delay in the locks. It is for this same reason that vessel interests look with resentful eyes on the proposition to divert ten to fourteen thousand cubic feet down the Mississippi Valley through the Chicago Drainage Canal. This must appear to them a last insult. But this loss of eight or nine inches of draft, even though it cost a million or two dollars a year in increased freight charges, is trifling compared to the loss coming from the régime of low Lake stages. Whatever the cause of low water may be, it is a fact. In Lakes Michigan-Huron and reaching up St. Marys River to the lower entrance of the "Soo" locks, in the St. Clair and Detroit rivers and in Lake Erie it exists. Lake Superior is all right, and Lake Ontario may get

* For the benefit of a member of this Society, who said to me one day that we government men up in the Jones Building had a *close corporation*, I will say that Colonel Davis' office covers the third floor of the Jones Building. The Lake Survey has 8 rooms in the Campau Building and 8 rooms in the Old Federal Building, all on Larned and Griswold streets. I shall be glad to exhibit our work there at any time.

even uncomfortably high. I will speak later of the reasons why these latter lakes are well up.

Colonel Davis, in his reports on the 20-ft. channel, has for several years past reiterated — like the *Carthage must be destroyed* of the Roman Senator — this statement: "The improved channels were made available in 1897, but as the water levels have been *almost continuously below the mean stage*, the actual navigable depth has been *1 to 3 feet less* than 20 feet."

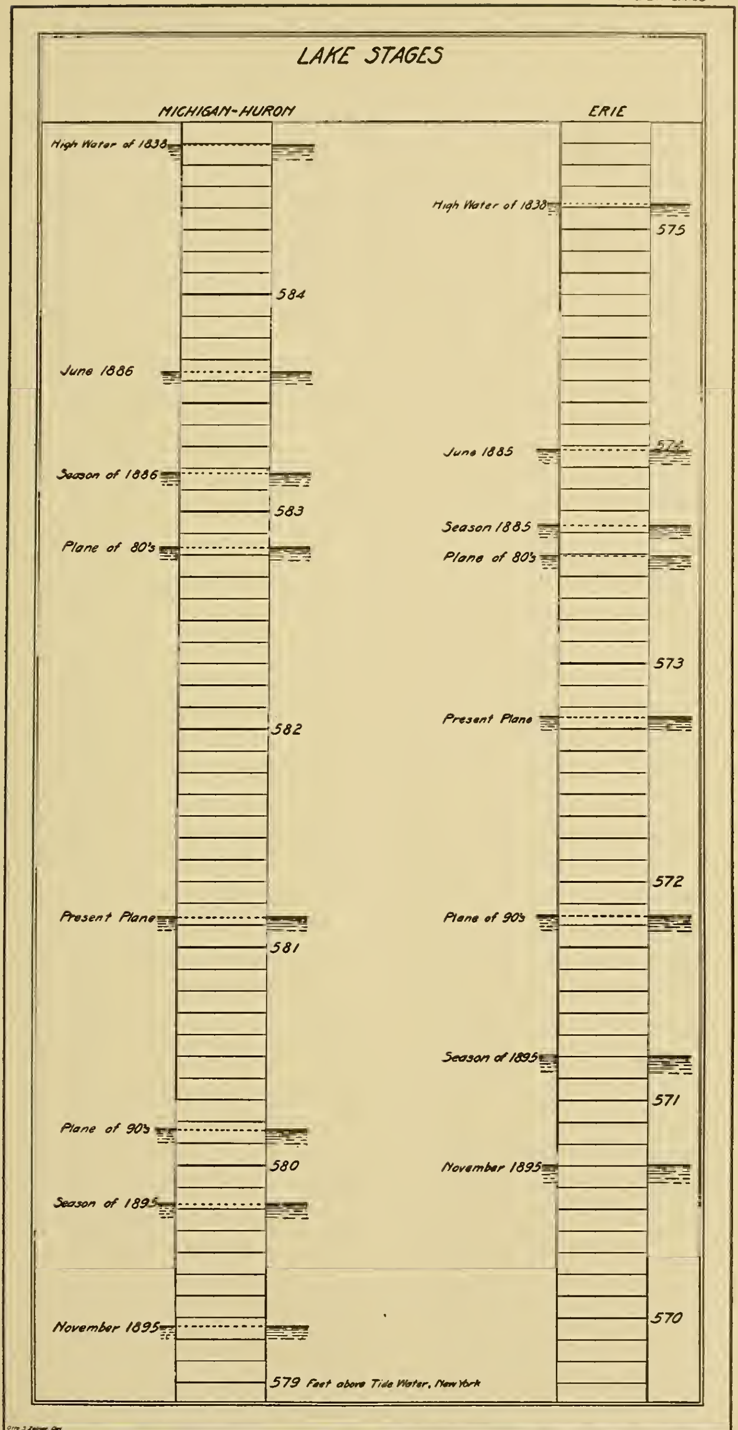
Remembering that a change of one foot draft on the big carriers means ten per cent. of load, the three feet lost mean over 27 per cent. of the cargo-carrying capacity destroyed; so that freight which should cost $1 a ton on 20-ft. draft, costs on 17-ft. drafts nearly $1.37; and as the consumer generally pays the freight, you and I pay more for bread and coal and lumber and steel and every product into which these enter, on account of low water.

Not all the vessels of the lakes could load to 20-ft., — some of them are light draft, — but any figures that deal with ten or twenty years in the future may assume that the bulk, the big percentage of the freight, will be transported in vessels capable of deep-draft loading, — and subsequent figures will rest on this assumption.

Taking up Lake Michigan-Huron first, and remembering that the level of water in the lake affects the St. Marys River to "Soo" locks, and the St. Clair River, the mean elevation during the seasons of navigation for the 5 years, 1883–1887 (I shall speak of this as the *plane of the '80s*), was 582.8. It was considerably higher than this part of the time; 9½ in. higher during June, 1886, and 4 in. higher as a mean for the season of navigation of 1886. Plate 1 illustrates these levels.

Since this good Lake level existed as a *state* of *nature* for five years, and only twenty odd years ago, a *return* of the Lake to this level could not cause shore encroachments that might be logically resented or resisted; and as engineering works of importance have been constructed with a full knowledge that a series of wet years may bring the Lake back to this prior level, no damage should result. What is known as the *high water of 1838* was 23 in. above the *plane of the '80s*. During the past season the mean stage of the highest month, July, was 15 in. below this *plane of the '80s*.

Now I do not wish to commit myself to any particular Lake level as the right level — I am discussing the principle rather than definite limits — and this *plane of the '80s* is a convenient and defensible illustration.


LAKE STAGES
MICHIGAN-HURON
ERIE
High Water of 1838
584
June 1886
Season of 1886
583
Plane of 80's
582
Present Plane
581
Plane of 90's
580
Season of 1895
November 1895
579 Feet above Tide Water, New York
High Water of 1838
575
June 1885
574
Season 1885
Plane of 80's
573
Present Plane
572
Plane of 90's
Season of 1895
571
November 1895
570

From 1895 to 1899 was a five-year period of low water; I shall call the mean level during the seasons of navigation of these years the *plane of the '90s.*

This *plane of the '90s* is for Lake Michigan-Huron 2.6 ft., or 31 inches below the *plane of the '80s;* and in the season of 1895 the water was 3 ft. below the *plane of the '80s.* In November, 1895, it was 4.4 ft., or 53 in., below the level of June, 1886. That is, between *planes of the '80s* and *the '90s* there is 2.6 ft.; between extreme years, 3 ft.; between extreme months, 4.4 ft.

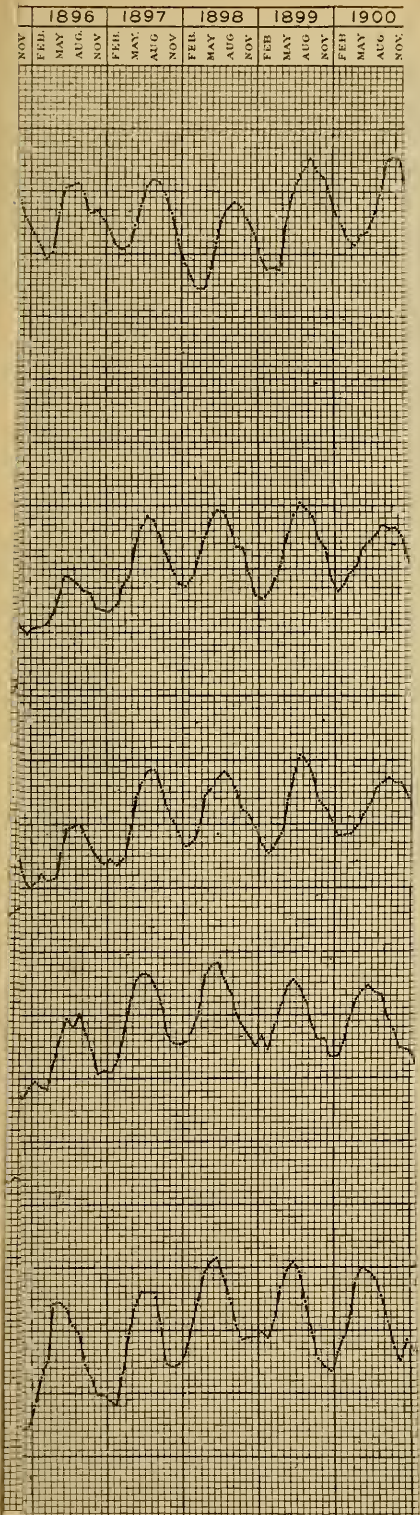
For 4 years now the level during the season of navigation has been much the same as during 1907; I shall call this the *present plane.* It is 1.7 ft. or 20½ in. below the *plane of the '80s,* with a loss of 14 per cent. in the carrying capacity of the heavy freighters, or 1 400 tons loss for each trip of a big carrier.

For Lake Erie the *plane of the '80s* is 573.5, and that of the *'90s* is 1.6 ft., or 19 in. lower; and during the season of 1895 the lake was 2.3 ft., or 28 in., below the *plane of the '80s;* and the change between single months is over 4 ft., as on Michigan-Huron. The *present plane* is only 9 in. below the *plane of the '80s.* This good stage of Lake Erie is likely to retard regulation, because it is not uncomfortably low; but the recurrence of the low water of 1895 is very certain, with a loss of carrying capacity of over 20 per cent. as compared with the *plane of the '80s.*

Please do not think I speak as a discoverer of the regulation of Lake levels. Roosevelt, you know, is charged with having discovered the Ten Commandments, but Moses had a whack at them some centuries before. Regulation is not quite so aged or quite so urgent as *some,* at least, of the Ten Commandments, but it is very far from new. The need of it was recognized fully in the early '90s, and the low water of 1895 brought the discussion to an acute stage. In 1898, the late Mr. George Y. Wisner, past president of this Society, as a member of the Deep Waterways Commission, urged the building of controlling works in Niagara River. In this project Lake Michigan-Huron was to receive its benefit by back-water effect only. It was estimated, as I remember it, that a rise of three feet in Lake Erie would raise Lake Michigan-Huron one foot.

At the present time another of our past presidents, Dean Haskell, of Cornell, as a member of the International Waterways Commission, is working anew on the problem of controlling works in the Niagara River.

The Lake Survey's part in these investigations, so far, is to


1896
1897
1898
1899
1900
NOV
FEB.
MAY
AUG.
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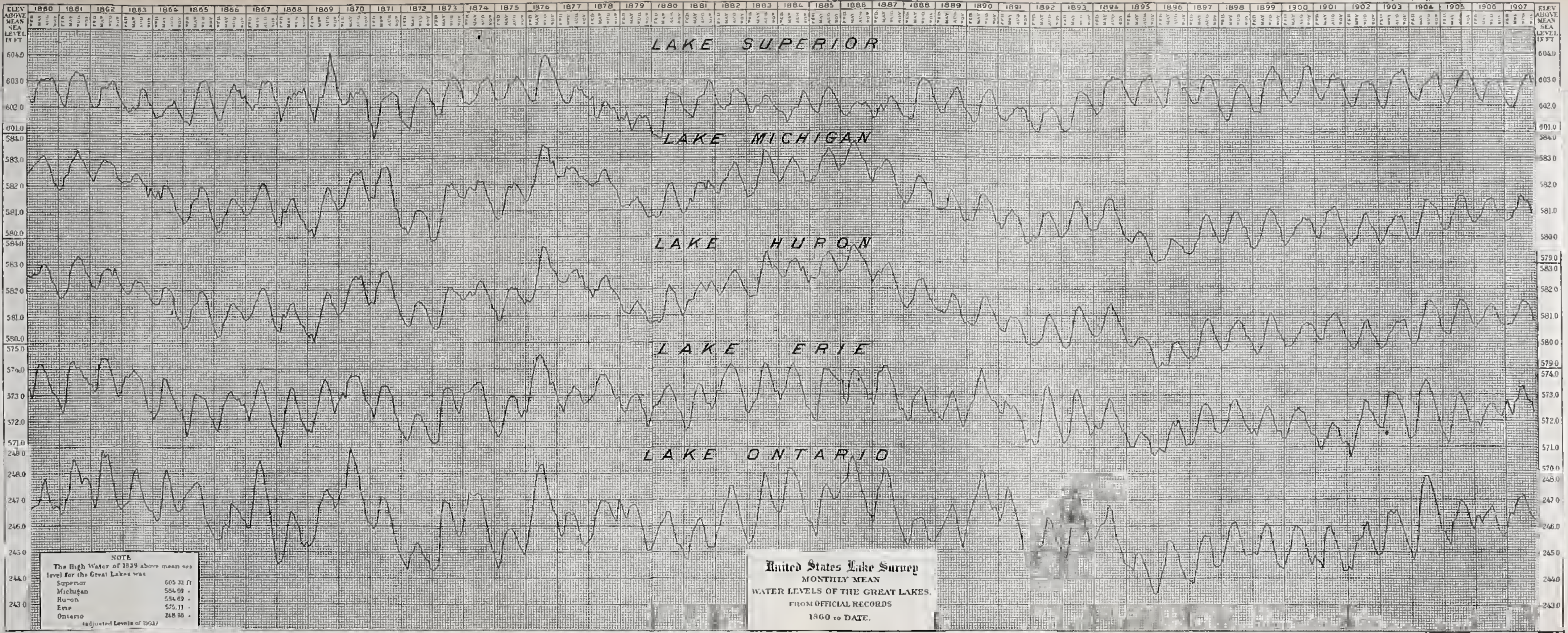
ELEV ABOVE MEAN SEA LEVEL IN FT
1860 1861 1862 1863 1864 1865 1866 1867 1868 1869 1870 1871 1872 1873 1874 1875 1876 1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
NOTE
The High Water of 1839 above mean sea level for the Great Lakes was
Superior 605.32 ft
Michigan 584.69
Huron 584.69
Erie 575.11
Ontario 248.98
(adjusted Levels of 1903)
United States Lake Survey
MONTHLY MEAN
WATER LEVELS OF THE GREAT LAKES,
FROM OFFICIAL RECORDS
1860 to DATE.

gather the physical data, water levels, river flow, evaporation, and make studies of rainfall and the like.

Though this question was acute, as I have said, during the low water of 1895, it has been growing vastly more important since, because the traffic is nearly *four* times as great now as in 1895.

What are the *causes* of this *low water régime?* Take Lake Erie, for instance: In order to get a navigable channel down the Niagara River to Tonawanda, dredges and drills have gone in and breached the natural dam; the Erie Canal and the Welland Canal take some water for navigation and some for power purposes. The power companies at Niagara Falls are suspected of having something to do with draining Lake Erie, and the Lake Survey has their case under consideration at the present time, but with no decision announced. Whatever water goes down the Mississippi Valley through the Chicago Drainage Canal is at the expense of Lake Erie. It is possible that deforestation of the shores and the plowing of the land have lowered the run-off by increasing evaporation, and are contributory causes.

Variations in rainfall and evaporation account for periodic low and high water. Each season the lakes rise with the early summer rainfall and run-off, and fall as the days grow drier. The seasonal curves are shown in Plate 2. This movement would be much reduced by controlling works.

If it be done *brutally*, it is exceeding easy to raise the level of one of the Great Lakes. Lake Superior, the biggest of all, was raised 6 in. by bridge piers and a wing dam at the head of the rapids in St. Marys River. The cross-sectional area of the outflow at the crest of the weir was reduced, and Lake Superior had to rise to get its normal outflow back again.

Lake Ontario has been raised 5 in. by plugging up, in 1903, a small part of the outflow at the Galop Rapids.

I say this method of getting better navigable depths is *brutal* because it increased the seasonal movement, and reduced the power to regulate against *high water.* It lacks finesse and foresight. Lake Superior has, since the building of her power canals, avoided any possibility of destructive high water, but Lake Ontario may experience the discomforts, if not the dangers, of high water. December, 1907, shows for Ontario the highest water for that month since 1876.

The *danger* of a Lake that in masquerading as Mr. Hyde cannot go back to Dr. Jekyll, in its destructive possibilities does not need to be dwelt upon. We want in the Lakes a condition of comfortable fullness, not *intoxication* nor the *orgies* that may

accompany a debauch. It is because of this danger of overfullness that the first move in Lake regulation needs to be for bigger outflow capacity than nature provided. You cannot regulate against high water otherwise. Back in the early '90s our president, Mr. Wheeler, gave out this principle, and I believe it to be fundamentally sound. There are some corollaries to this proposition, regarding independent outlets, that Mr. Wheeler may wish to speak about.

How are the lakes to be regulated? What form of controlling works? That is too large a subject to enter upon at this time of night.

Nature has a method of regulation that is excellent, so far as it goes. In the cold months, — January, February, March, — ice in the St. Lawrence River checks the outflow, and the average depth of water impounded by this winter regulative force is 7 in. on the surface of Lake Ontario. In the St. Clair River ice jams occur, and the outflow is reduced at times from a normal of 200 000 cubic feet to 74 000. Mr. L. C. Sabin, a member of this Society, computed the impounding value of ice in St. Clair River in 1901 as over 6 in. on the surface of Lake Michigan-Huron.

When the spring comes these controlling works of ice go out, and not a vestige of the apparatus remains. The channel has returned to its full unimpeded capacity. If these ice jams were placed only when *needed*, and kept in place as *long* as they were needed to accomplish the desired results, the system would be perfect. In the end engineers must take their cue from nature in this, but not to the extent of using ice jams, — dams or caissons rather, to reduce critical areas, as flashboards reduce the outflow area of a milldam.

I feel sure the *reinstatement* and *upholding* of the Lake levels will come; that the caprice of nature will be superseded by human foresight. I believe it is a worthy engineering project. The water of the Lakes is too valuable to run off without yielding up the full good that is in it. It is needed for vessel tracks, for sanitation and for scenic grandeur and water powers, as at Niagara Falls. There are 5 000 000 horse-powers in the vicinity of the Cataract at Niagara.

I spoke before of the vitality of the Lakes coming from the water. Low water is disease. The Lakes were sick in the '90s. The present semi-strength is only a rally, not convalescence. The bleeding must be stopped before the patient will know again the fullness of health, and here is a chance for engineering medication.

The spectacle of the volume of commerce grown to tremendous proportions — it is more than a third of the national commerce — while the tracks have dropped down to *inefficient levels*, is not a pleasant one. The process of dredging the bottom to keep pace with falling surface levels is a tedious and costly *stern chase*.

It is a much better proposition to uplift the Lake levels and let the water at one stroke come pulsing back into every harbor and channel, restoring and retaining the fullness of the '*80s*. That will mean good roads on the right-of-way of the Great Lakes.

Now, in closing I want to say that the steamer track from Duluth to Buffalo is 985 miles long; and the length of this paper is about the same. I thank you for your patience; I can excuse myself only as Tom Reed did when accused of running a billion dollar *Congress*. He said: " This is a *billion dollar country* " — and my paper to-night is *on* a *985-mile subject*.

[NOTE. — Discussion on this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1908, for publication in a subsequent number of the JOURNAL.]

MECHANICAL ENGINEERING AS PRACTICED ON THE ATLANTIC AND PACIFIC COASTS.

By George W. Dickie, Member of the Technical Society of the Pacific Coast.

[Read at the Annual Meeting of the Society, January 24, 1908.]

After spending thirty-five years in the practice of engineering on the Pacific coast, I am now spending a year and a half superintending work of a similar character on the Atlantic coast, and I find myself among new conditions and new methods. In this paper I will endeavor to compare, from an engineering standpoint, conditions as I find them here with those that obtain on the Pacific coast.

The Atlantic states, which front on the long Eastern seaboard, have been five times as long under development as the Western states; their population is much more numerous within a similar area; the markets for the products of their industries, both domestic and foreign, are correspondingly more extended and varied; their transportation facilities much more highly developed and convenient. Their great population supplies them with workmen, makes necessary the enterprises which demand the product of their engineering establishments, and their facilities for transportation put them in close touch with their markets. While the volume of business is so great, it is so not so much because of new demands for new machines to obtain new results, but rather for the same machines to do the same thing in a new locality or to increase the output in the same locality. Consequently, we find mechanical engineering establishments devoted entirely to the production of one machine or class of machines, where every part has been standardized, special machines installed for the cheapest possible production of every part and special workmen trained to get the largest output possible from these special machines. This condition is possible only where there is a large market for a special type of machine.

On the Pacific coast the conditions which would make such a system possible have not hitherto prevailed. Its manufacturing cannot be applied to the production of special machines, for the conditions which demand such a manufactory do not exist. The machines made there are not manufactured, but built one by one. Because of the variety of output which an

engineering establishment must produce in order to live, special machines to produce any one part are out of the question and workmen good at only one operation cannot be profitably employed. The Pacific coast establishment is, therefore, an engineering shop and not a manufactory, and in it anything possible in mechanics can be designed and built with a very fair prospect of meeting all the requirements demanded of it, but all the engineering skill used in the design and construction of this one machine goes with it, although it is quite as great as that required in a manufactory for the production of a thousand such machines; consequently the Western engineer must be constantly exercising his skill, experience and ingenuity in the design of new machines to keep his shop going, while his Eastern brother, having perfected a design to meet the general requirements of "the trade," may set his brain to work on eliminating all sources of loss in the system he has established for producing his machine at the lowest possible cost.

The principal difference is then this, that whereas the engineer in the West devotes his time and skill to meet the requirements of each customer, the engineer of the East perfects one machine to meet the requirements of all his customers and spends his time and energies in producing it at a cost that will insure it a ready sale in the open market. This difference results in the manufacturing, mechanical engineer of the East being able not only to undersell his brother of the West in machines that the general market requires in manufacturable quantities, but in many cases to successfully enter the markets of Europe, where the unit price of labor is much less than that obtaining in his own establishment.

On the other hand, should a client approach an Eastern shop with the outline of some piece of mechanism to meet some new condition, the development of which requires thorough and general mechanical skill, and, after the plan is developed, individual skill on the part of the workmen in the shop, to produce it, he will find great difficulty in getting a shop to undertake to carry out his ideas, and should he find one willing to serve him he would probably be surprised at the excessive cost of the undertaking. On the Pacific coast this original class of work is continually being made and the engineer and his shop are by constant practice ever ready to take hold of and carry to successful completion anything possible in mechanics, and that at a cost not much if any greater than ordinary work of the same complexity.

The reason for this is to be found in the difference in shop organization brought about by the variance in the trade conditions between the one locality and the other. In the East a thoroughly organized and often very complex system, working harmoniously along lines that are the result of careful study and much experience, produces a machine as perfect as the system of which it is the embodiment, irrespective of the mechanical ability and general knowledge of the operators. The workmen acquire highly specialized skill carrying out instructions according to the system, the staff becomes highly expert in applying and perfecting it; the system itself is or may be made perfect in obtaining the result for which it is intended; applied to a new condition it loses its efficiency in a greater or less degree, according to the amount of the deviation from the beaten track. In the West, on the contrary, owing to the necessity of turning out a product as varied as the mechanical needs of a new and developing country, a shop cannot have any particular system, except that of a general organization which must be elastic enough to adapt itself readily to widely different kinds of product, where no foresight can possibly prepare for the work that must next be undertaken.

The planning may be and often is along original lines, without precedent or general experience to guide the designer, and when the design reaches the shop where it is to be made, its growth must be carefully watched, for often the thing in metal does not look like its image in ink; the working mechanic may often be able to save the reputation of the designer by timely advice, the result of his practical experience with metals and his skill in working them. Hence, not only must the designing staff be able to design any kind of a machine that a customer may require, but his workers must also be mechanics of great skill and general experience to bring safely into working form the design that has just been brought from the fertile brain of his chief.

In the one case a perfect system produces at the least possible cost a perfectly planned and experimentally adjusted design without any skill on the part of the workman other than that required to perform his part in the system. In the other case a machine to meet special conditions is designed as skillfully and as perfectly as the engineer's skill and experience enable him to design it; it is built by skilled mechanics under a system that enables the designer or the skilled workman to modify the design at any stage of the production should occasion require it.

There are two principal points of view from which to observe the results that follow from the workings of these two radically different methods of production. They may be viewed from the position of the capitalist and from the position of the working man or operative, both of whom are involved.

A shop with the system so much to be seen in the Atlantic states, looked at from the capitalist's position, is a profitable investment for his surplus or inheritance and tends to create an upper class or controlling power in mechanical engineering.

Looking at it from the operative's position we see the extinction of all individual effort on the part of the mechanic to improve the product of which his work forms a part; lack of interest in his work, due to the repetition of the same operation on the same parts of a machine that he never sees finished; no prospect of a better condition or increased pay. Above the workman we see an array of college graduates operating the system and assigning the work to the operatives; above these the controlling head, whose engineering skill contrived the system and the machinery through which it operates, the man who has the confidence of the capitalist and whose position is established as long as the supply of skill to operate the system is plentiful, and this is secured by the yearly turnout of the technical and other colleges.

The shop organization on the Pacific coast from the capitalist's position is not so good; it shows no prospect of a large return to the investor, owing to the varied character of the product, each item of which involves new problems which, when solved, have no application to those succeeding them. The controlling head of the work has not the same security in his place as his Eastern prototype, for every day brings a fresh problem, requiring new applications of mechanical engineering skill; his power to work out these new problems is his worth, in virtue of which he retains his position and its emoluments. The problem he solved yesterday is not in itself a solution of the problem of the future; he cannot sustain himself on the success of the past. When the continual strain has told on his store of brain energy and he begins to blunder, he can no longer hold his post and is replaced by a younger and fresher man. He has not an automatic system to fall back on; he himself is the system.

From the working mechanic's standpoint the Western methods of shop organization present a brighter prospect. The better paid positions must be filled by men who know the things they order made and who have learned in the school of experi-

ence. Those whom they work under must necessarily have traveled by the same way in which the mechanics now are. To his ambition the view is promising; his brains and mechanical skill are assets of great possible value; he feels that by perseverance he may better his condition and obtain the better fortune to which he aspires. It is, then, from the viewpoint of the man who is willing to think, and work, to the progressive man, that the Western method appeals to us.

Let us examine these matters from the neutral position of those who are neither capitalists nor operatives, but who are interested not only in the progress of mechanical engineering, but also in the general prosperity of all their fellowmen. Such a view must take cognizance of both the ethic and economic effects of any system of production. It is from this point of view that I intend to look at the system which obtains in many large engineering establishments on the Eastern coast. The economic effect of the system from the standpoint of cheap construction is undoubtedly good, for it reduces the cost of the machine to the lowest possible point obtainable with the current rates for material and labor and thus enables the producer to reach markets that would otherwise be closed to him; it enables him to secure capital to extend his operations, because he can figure on the actual cost of production and the profits that can be secured. It is his system which enables him to eliminate the uncertainties of skilled labor and the difficulty of knowing how it will act.

Much of the work that under the simple organization of the West is done by the work's manager is done by a skilled force of computers, whom the system supplies with a great deal of more or less exact data which enable them to figure exactly what each man may be expected to do.

In his very interesting and elaborate Presidential Address on The Art of Cutting Metals, read before the American Society of Mechanical Engineers, Mr. F. W. Taylor gives a very complete history of the system that he has largely been the means of introducing, whereby the possible amount of work of any tool on any known character of material is computed on a special slide rule by a man trained and experienced in this work. This address, which amounts in its scope to a treatise, is undoubtedly of a high order of merit and is the most valuable contribution to engineering literature that has been made of late years; but in some particulars I wish to take exception to the methods advocated by its author. The result as obtained by the slide

rule is the work demanded of the operative. Mr. Taylor informs us that his greatest difficulties have been with skilled mechanics, men whose characters and abilities he had to respect, but who would not give up their habit of thinking for themselves; they refused to accept the decisions of the slide rule and had to give way to the man who was content to carry out instructions. As I thought of the result of this, and, like the men who had to be replaced, I could not help thinking, another way occurred to me, whereby the same result was obtained without dismissing the thinking workmen. While studying the system in operation at some large establishments in England, wherein the workmen as a body contract to do all the labor involved in the production of any given piece of work, I happened to be looking through one which had for a long time practiced this method. Observing an old machinist, with an interesting face, at a large lathe, I talked with him about this system and asked him whether it stimulated the men themselves to think of the cost and the quickest way of doing their work. In replying, he pointed to a young man working a smaller lathe nearby and said: " Now, there is a young man who came here from Glasgow some weeks ago; he is a good lathe hand, he knows everything that can be done with a lathe and does it well; we had to teach him only one thing and that was how *much* a lathe can do." This method arrives at the same result as Mr. Taylor's slide rule in obtaining the maximum output from each machine, and its moral effect is good. The moral effect of the system that has enabled the American manufacturing engineer to secure and hold markets, not only in his own country, but also in foreign countries where the workman does not secure anything like the wages paid to the American mechanic, cannot be called good.

I have tried to observe the condition of the workman under the slide rule system as compared with the condition of those who work in shops where the varied nature of the work does not admit of a system that may be rigorously carried out, but where the results obtained, both mechanical and economical, depend largely on the individual mechanical ability and moral character of the working man. The tendency of the rule system is to deaden all individual effort on the part of the working man; his interest in his work ends with the accomplishment of the task worked out for him on the rule; his outlook is not brightened much, even if he succeeds in beating it, as this feat means only a few cents more in a given time; he receives no stimulus from the completion of any finished piece of mechanism that he

has produced; he only sees gathering around him on the one side a pile of rough blanks all alike, which he, or rather the machine he operates, converts into another pile of finished parts all alike; that is all he sees and knows of the part he plays in a great industry. There is no nourishment in that work for the brain, and that man cannot grow; in fact, he loses the power to think and the desire to grow; he swiftly and surely becomes the automaton that fits so well into Mr. Taylor's slide rule system. Therefore, I say, the moral effect is not good — but how else is it possible to reach the market with a product that may be profitably sold at the price the market offers? The mechanical engineering establishments in the Eastern states have developed and perfected systems along these lines which are successful in making profits for the investors but have an immoral tendency towards destroying the independent, thinking mechanic.

The time is fast approaching, if it has not already come, when the Pacific coast engineering establishment must take special lines of work and perfect a system of manufacture that will at least secure for it the local market for its product; when that is secured, its growth will be commensurate with the growth of the population and commerce of the place. Is it possible to secure the economy of what I will call the slide rule system by some other method that will not displace the skilled mechanic? Is there, on the other hand, any system of management that will enable engineering establishments on the Pacific coast to continue doing business under the conditions that now obtain, where time wages are higher than in any other part of the world, and where to offset this the economic conditions of operating are low as compared with any system that determines the amount of production per unit of time? After careful study of conditions in the West, I am forced to the conclusion that unless a radical change is made in the method of doing work, mechanical engineering as a business will sink to the level of the small jobbing shop. These conditions, bad as they have been, are steadily growing worse. The workmen seem to forget that with modern means of transportation no section of this country, great as it is, can maintain conditions so radically different from those prevailing in other parts, as now attempted by them; the terrible condition of industrial engineering in this part of the country, where we were always proud of our high class workmen, is directly due to the forced and artificial value placed on labor by labor itself. It is hardly possible now to

go back to old conditions of hours and wages. If we are to continue to produce what we require of machinery, those managing the establishments that are to produce it will have to find out honestly what part of the possible selling price can be given to the workmen who convert the raw material into the salable machine, and contract with them or their representatives to do all the work for that amount; in that case the men can work long or short hours, as it may suit them; each man will be compelled by his fellows, who are his partners in the contract, to do his fair share of the work in order to obtain his pro rata of the reward. I have written so much on this method that to extend this proposition further would be only repeating what I have already said in great detail.

I do not think that the methods I find so extensively adopted in the East can be put in operation on the Pacific coast unless the present force of mechanics now usually on strike is entirely eliminated and a new race of operatives, willing to work under the slide-rule system, is introduced. Either the slide-rule system and a fresh supply of labor, or the contract system and the present force, must step in to save this struggling and now almost expiring industry.

A few months ago I had occasion to purchase a number of machines of a type that I had perfected on the Pacific coast to meet the special requirements there; the demand on the coast required about twenty of these machines each year and I used to make them in lots of twenty at a time, not so much for profit as for filling in and keeping the small tools in work. They were sold at $900 each and at that price they paid for material, labor and a pro rata of general expenses. I required sixteen of these same machines for the purpose I refer to and had the drawings from which they were made in San Francisco. The same machines I bought for $500 apiece at an establishment in Maine, where the facilities in tools and handling apparatus are not so good as in San Francisco. About sixty of these machines are now being made at the same establishment for the Pacific coast trade, and the business of making them there is stopped. The labor cost of this machine in San Francisco was $530, while the labor cost in the East is $210; adding the cost of transportation entirely to labor, the amount available for wages to operatives in San Francisco, assuming, of course, that the general expense and profit amounted to the same thing in these two cases, is $315. Since interstate commerce is free and unrestricted, the transportation charges represent the difference

available in the possible prices obtainable in the East and the West for such a machine as a continuous manufacturing proposition.

To so alter your conditions in the labor market that you may compete with the Eastern states is a present necessity if you would secure in mechanical engineering future prosperity. A change must come in the relations of employers and employed; a more intimate connection and co-relation must be established. To make the mechanic understand that there are practical and economically impassable limitations to the achievement of short hours and high wages; to make him realize that the price of any article being fixed, the amount available for labor is also fixed; to bring the employers to believe that the only way to prevent strikes and secure a lasting industrial peace is to have a thorough understanding between themselves and their employees as to the amount in the cost of any product that may be applied to compensate the workman for his toil; to teach employers the justice of frankly figuring out with their employees the cost of materials, expense of operating, profit required and amount available for labor; in short, to establish a just balance and to apply the Golden Rule to industry is the great problem to be solved by those interested in the development of engineering industries on the Pacific coast. Strikes and lockouts will never settle anything in industrial economics; their object is to destroy and in this their success is beyond dispute; as a means of settlement for any misunderstanding that may exist between employer and employed they should at once and forever be done away with, as entirely too crude for this age of enlightenment and progress.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1908, for publication in a subsequent number of the JOURNAL.]

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FURNACE DESIGN IN RELATION TO FUEL ECONOMY.

BY E. G. BAILEY, JUNIOR MEMBER AMERICAN SOCIETY MECHANICAL ENGINEERS.

[Read before the Boston Society of Civil Engineers, December 18, 1907.]

IN designing a boiler plant, the ultimate object is to obtain the required steam at the desired pressure, temperature or quality at the least cost. The least cost does not include the coal bill alone, but, in addition to this, consideration must be given to cost of labor necessary for the operation of the plant, repairs, interest and depreciation on capital invested. A saving in the fuel bill alone in new plants or furnaces is not sufficient to prove conclusively that any particular design is the best. The labor necessary for economical operation, together with more rapid burning out or wear of certain parts, may more than offset the saving due to boiler efficiency alone.

The majority of the boiler plants in New England running 24 hr. a day consume in one year coal amounting in value to more than the original cost of the plant, so that it would pay to tear down a new steam plant before it had ever been operated if you could prove that by so doing you would make a saving of 5 per cent. There are many plants which have been in operation five or ten years that could be reconstructed to-day at a saving of 5 or 10 per cent. The question is, Why do they continue to operate that plant when the coal being used each year costs more than did the plant when it was originally built? In most cases it would be necessary to make only a few changes to greatly increase the efficiency. In order to determine what saving might be made in the design of furnaces, it is necessary to know

the magnitude of the various losses as they exist under the present conditions. It is useless to expect a saving of 20 or 30 per cent. from the use of certain auxiliary apparatus, as is often claimed, when the losses supposed to be reduced are far from being as great as the contemplated saving.

The heat balance of a boiler test as given usually includes the following distribution of the total available calorific value of the coal:

(1) Heat used for evaporation of water in boiler.

(2) Loss due to latent heat in moisture formed from the combustion of coal.

(3) Loss due to products of combustion, or sensible heat of gases produced exclusive of excess air.

(4) Loss due to air excess, or sensible heat of unused air leaving boiler.

(5) Loss due to unburned gases, consisting of carbon monoxide, hydrogen and hydrocarbons.

(6) Loss due to unburned coal or coke dropping into the ash pit or passing through flues or up the stack.

(7) Loss due to radiation from boiler setting and absorption by brick setting.

The relative magnitude of the above losses varies greatly, depending upon the kind of boiler, furnace, rate of combustion and method of firing. The results recently determined from 18 evaporation tests on a 200 h. p. return tubular boiler, hand fired, give some idea of the relative importance of the various losses as they occur in a stationary plant. The average of the above tests is as follows:

1. Heat used for evaporation	66.7
2. Loss due to latent heat	2.7
3. Loss due to products of combustion	8.5
4. Loss due to air excess	8.5
5. Loss due to unburned gases	0.8
6. Loss due to unburned coal	2.4
7. Loss due to radiation and absorption	10.4
Total heat	100.0

The important item is the heat used for evaporation or the boiler efficiency, which can be increased only by the reduction in one or more of the various losses as they now exist. The extent to which these losses may be reduced is dependent upon the kind of coal, method of firing or supply of coal and air, conditions under which combustion takes place, and extent and conditions of heat-absorbing surface.

Latent Heat or Moisture in Coal. This loss includes not only the evaporation of the moisture in the coal as usually determined, but that formed from the combustion of hydrogen as well. This loss is of small importance and varies but little for the different coals received in this market. It is a loss that is impossible to reduce, but it may be prevented in certain cases where coal is intentionally wet by the fireman. This is universally done on a locomotive, but it is necessary in this case to lay the excessive dust that would otherwise make the work very disagreeable.

Products of Combustion. The amount of gases produced from the combustion varies almost directly with the calorific value of the coal, so that the percentage of loss is practically constant except for variation in the flue temperature.

The temperature depends upon the rate of combustion, area of boiler heating surface and cleanliness of the same.

Air Excess. This loss is one of great importance, as it often exceeds 30 per cent. It not only carries away sensible heat, but reduces the furnace temperature, thereby reducing the efficiency. This loss may be affected to some extent by the character and quality of coal burned. A non-coking coal generally lies closer together and is less apt to allow holes to burn in the fire than a coking coal; also the formation of clinkers causes the air to pass through the fire in streams, thus causing high velocity in certain parts, and a hole is the result.

The fireman is largely responsible for the loss due to air excess because he does not keep the fire to the proper thickness for the draft, or he may fire the coal unevenly, allowing holes or thin spots to form. A series of tests was once made to determine the air excess with different thicknesses of fire, with uniform conditions with respect to draft, kind of coal, etc.

Thickness of Fire.	Air Excess.
4 inches	135 per cent.
6 ,,	92 ,,
8 ,,	75 ,,
10 ,,	62 ,,
12 ,,	50 ,,

These results were taken at the rear of a B. & W. boiler and include some air which leaked in through the setting and probably amounted to 20 or 30 per cent. The saving was 6.5 per cent. between the 12 and 4-in. fires.

The best method of determining the extent of this loss is by analyzing the gas leaving the boiler. This is usually done with the Orsat apparatus, but the automatic continuous recording

CO_2 machines now on the market make it much easier for the fireman to keep his fire in good condition, and the effectiveness of his work is permanently recorded. The tendency on the part of the fireman is to disregard such an apparatus, especially after it has gotten out of repair once or twice, but it is only through interest on his part that economical results can be obtained. A year's records of the past results will not increase the boiler efficiency. One per cent. of CO_2 means about 20 per cent. air excess, or 2 per cent. loss under average conditions of air excess and temperature.

The air excess as determined at the uptake from a boiler or at the bottom of the stack does not always show what the fireman is doing, as the air leaking through cracks in the brickwork, around clean-out doors and even the porosity of the brickwork, is oftentimes as great as or greater than the excess air passing through the furnace.

Results obtained from various plants show some interesting conditions, giving both extremes of air excess and the increase due to leakage through the boiler settings, flues and economizers.

From 250 h.p. Cahall boilers, hand-fired, burning New River coal, the CO_2 averaged above 16 per cent., corresponding to an air excess of about 15 per cent. The CO did not exceed 0.7 per cent., with a loss of about 1.4 per cent. of the heat in the coal. The same boilers burning No. 3 Buckwheat and Pennsylvania bituminous mixed in the ratio of 2 to 1 gave about 60 per cent. air excess.

A plant with 9 horizontal return tubular boilers were operating with a steam blower producing forced draft in the ash pit. With the blowers on, several gas analyses averaged 59 per cent. air excess and 1 per cent. CO, making a loss of about 4 per cent. due to each. When the blowers were shut off by the damper regulator the air excess went as high as 209 per cent., making a loss of 15 per cent., as compared with 8 per cent. when the blowers were in service. This high air excess resulted from the restricted area into the ash pit and the higher vacuum in the firebox, causing a large amount of air to pass in through the leaking brickwork of the boiler setting.

A plant with 20 horizontal return tubular boilers, hand-fired, gave 150 per cent. air excess leaving the boilers, and 180 per cent. leaving the economizer.

A number of tests made on a B. & W. boiler with Dutch oven furnace gave 35 per cent. air excess leaving the combustion chamber and 75 per cent. leaving the boiler setting.

A stoker-fired plant with eight 350 h.p. boilers gave 146 per cent. air excess over the fires, 230 per cent. entering economizers and 280 per cent. entering the chimney. The loss in this case amounted to about 30 per cent., due to air excess.

A hand-fired plant with several vertical fire tube boilers gave 90 per cent. air excess leaving the boilers and 250 per cent. leaving the economizer.

A chain grate stoker gave 240 per cent. air excess, the air leaking largely around the back end of the grate.

Unburned Gases. Usually the analysis of flue gases gives the carbon monoxide as the only unburned gas, but there are undoubtedly other gases that are not completely burned that are of higher calorific value than CO. They are seldom determined, owing to the difficulty of the determination. With the CO_2 about 10 per cent., the loss due to 1 per cent. of CO means about 5 per cent. of the calorific value of the coal. Under the same conditions, 1 per cent. of CH_4 means a loss of 16 per cent., and 1 per cent. of C_2H_4 causes a loss as great as 30 per cent. These and other hydrocarbons are very likely present in many furnaces where conditions are not favorable to complete combustion. In series of tests with an increasing per cent. of CO, the radiation and undetermined loss generally increases accordingly, indicating that there might be unburned gases escaping undetermined.

The combustion of these gases cannot be completed without sufficient oxygen thoroughly mixed at a high temperature. In order to accomplish this the furnace and boiler should be designed so that the heat will be generated in one and absorbed by the other. Both operations cannot take place at the same time and insure complete combustion.

The difficulty of obtaining the proper conditions increases with the per cent. of volatile matter in the coal burned. Smoke is an indication that these losses are occurring to a greater or less extent, but a smokeless stack does not necessarily indicate complete combustion.

An internally fired boiler is the most extreme case of violating the laws governing economical combustion with bituminous coals. It is practically impossible to prevent smoke under such circumstances, as some of the burning gases are extinguished by the lowering of temperature when the flame comes in contact with the water leg or enters the tubes.

Gas coal can be burned without smoke if the laws of combustion are properly considered and the furnace constructed so

that they can be carried out. The speaker had occasion to spend a month at a copper smelter in northern Michigan some years ago and there saw a case of complete smoke prevention. The larger smelters consist of a reverberatory furnace 30 ft. long and 17 ft. wide; the heat for smelting the ore comes from a furnace having a grate 8 ft. long and 11 ft. wide, which is separated from the smelter by a bridge wall only. Gas coal was being burned and contained about 35 per cent. of volatile matter. The method of firing was to put in 80 to 100 shovelfuls at hourly intervals. This is equivalent to firing 25 to 30 lb. of coal per square foot of grate per firing. There is a secondary air supply above and in the bridge wall, and the conditions for smoke prevention are evidently perfect, as the right amount of oxygen has plenty of time for thorough mixing in the smelter, in which a temperature of about 2400 degree fahr. is maintained.

Had a steam boiler taken all of the products of combustion from such a smelter, the boiler efficiency would probably not have been very high as a larger amount of heat would naturally be radiated from so large a firebrick combustion chamber. However it is evident that complete and smokeless combustion can be obtained by applying the Dutch-oven principle to the boiler furnace. Many hand-fired and stoker-fired furnaces are being used with a great deal of success so far as smoke prevention is concerned by making use of this feature in furnace construction. The more rapid the mixture of the oxygen and volatile gases, the shorter need be the firebrick combustion chamber, as the length of flame from various coals depends more upon the rapidity of mixture than it does upon the per cent. of volatile matter contained in the coal. The flame from anthracite coal and coke often extends 40 ft. from the bed of fuel.

The volatile matter is driven off from coal very rapidly after it is spread over an incandescent bed of coals. Some experiments were once made to determine the rate at which the gases were given off and the rate of generation of heat when coal was fired. The method of making these experiments was to put a certain quantity of coal on a wrought-iron grid and after it had been on the fire one minute it was withdrawn and the fire extinguished by placing the grid in an atmosphere of steam. This operation was repeated for different lengths of time with the same coal, and from analysis of the remaining coal or coke the loss in volatile and heat units was determined. A gas coal developed 30 per cent. of its total heat during the first five minutes and the volatile was reduced from 36 per cent. to 15 per

cent. A semi-bituminous coal developed 15 per cent. of its heat during the first five minutes and the volatile was reduced from 20 per cent. to 11 per cent. At the point of maximum liberation of volatile from the gas coal it was developing 1000 B.t.u. per minute. From these data the great variation in air required for complete combustion can be realized, and it is very doubtful whether there can be sufficient oxygen present at the critical time when coal is fired intermittently. The more uniformly the coal is supplied, the better the opportunity for complete combustion. One great advantage of the mechanical stoker is that it feeds the coal to the furnace continually, thereby holding the requirements for air in a constant ratio with the air supply. As none of the mechanical devices are perfect, they produce ideal conditions only to a certain extent.

Unburned Coal. In a stationary plant this loss is confined almost entirely to the coke or partly burned coal passing into the ash pit or drawn out the fire door with the ashes and clinkers. It varies with the opening in the grate, also with the per cent. of ash in the coal. The higher ash coals require more slicing and more frequent cleaning, and as the loss of partially burned coal varies with the working of the fire, it would naturally be greater. Some kinds of mechanical stokers are very wasteful in this respect unless careful attention is given to the part of the grate where the ashes fall off or are dumped intermittently. This loss from a chain grate stoker amounted to 16 per cent. in one test. In a locomotive the partially burned coal drawn through the flues is a very great loss; in some cases it was found to exceed 20 per cent. of the heat value of the coal. At the Pennsylvania Railroad locomotive testing plant at St. Louis they determined this loss to be about 8 per cent. by collecting the sparks, but after the tests were completed they found so many sparks on the surrounding buildings and ground that an estimation was made, which practically doubled this loss.

Radiation. This item of the heat balance is very difficult to determine directly, and is mostly taken by difference; hence it includes any errors made in the other determinations, as well as heat absorbed by the brickwork in the case of boilers with the brick setting. The latter error is one of frequent occurrence, as most tests are made under conditions more favorable to a higher rate of combustion and higher furnace temperature than during the 40 hr. previous. A paper read before the American Society of Mechanical Engineers some years ago gave the results of a 72-hr. boiler test on a B. & W. boiler burning Pocohontas

coal. The test was started with the brickwork cold, and after 60 hr. of firing the temperature of the wall rose 500 degrees fahr. The evaporation was checked every 6 hr., and there was a decrease of about 10 per cent. in the radiation loss between the first and latter tests.

Rate of Combustion. With the same difference in draft below and above the bed of fuel the rate of combustion varies with volatile in the coal; character of coal, whether coking or not; and upon the amount and nature of ash. In a high volatile coal a large per cent. of its weight is driven off regardless of the flow of air through the bed of fuel. A coking coal gives less area of opening through the fuel bed. Ash that does not clinker apparently reduces the rate of combustion but little. However, if this ash fuses at a comparatively low temperature, the clinkers formed reduce the amount of air passing through the grate by reducing the effective grate area by an amount equal to the area covered by the clinker. The more plastic the clinker the greater is this reduction in the rate of combustion, which is sometimes 50 per cent. within 8 hr. after the fire has been cleaned.

A great many smaller plants have difficulty in burning sufficient coal to keep their mill running, even with good coal. This result is usually caused by insufficient draft, as the horse-power required is beyond the capacity of the stack, or else other smoke connections have been added with no attention being given to the flow of gases. One case where two smoke connections met at right angles to the opening into the stack, and the velocity of the gases through this opening was 40 ft. per second, resulted in a reduction of 0.75 in. in draft through this one opening.

Another plant developing 1200 h. p. had a stack 4 ft. square and 85 ft. high. This stack would probably take care of the gases from 500 boiler h. p. unassisted by blowers. The plant in question had a forced draft fan connected to the ash pit of four of the seven boilers. The remaining three boilers had a draft of only 0.04 in. over the fire, so in order to assist the draft on all boilers, another fan was connected by a 16-in. pipe into the bottom of the stack and a current of cold air was forced up the stack. This would seem to be an inefficient method of producing draft, as the increased volume of air passing through the stack, which already is too small for the gases from the furnaces, and the lowering of the temperature of the gases in the stack, would both tend to reduce the draft. The only effective result would be the velocity of air entering the stack from the blower.

Coal Handling. The cost to handle coal from the cars or vessel to the furnaces varies considerably. In large plants, with coal-handling machinery and mechanical stokers, it can be handled for 18 to 20 cents per ton from barges, and 25 cents per ton from railroad cars. Where the coal is unloaded, passed and fired by hand, it costs from 40 cents per ton to as high as $1.25 in fair-sized plants.

DISCUSSION — at Meeting held February 12, 1908.

Mr. George H. Barrus (*by letter*). — 1. I am sure that Mr. Bailey merits the thanks and appreciation of the members of the Society for placing before them the results of his observations on fuel economy. I take it that most of the data given are based on the personal experiences of the author, and in this respect the paper is to be highly commended, for what we want most in these meetings is the report of practical results rather than untried theory.

2. I regret to find that the paper is in some respects disappointing. The subject, if we look at the title submitted at the previous meeting is, "Furnace Design in Relation to Fuel Economy." This appears to be a misnomer, for there is comparatively little in the paper that is devoted to the relation which furnace design alone has to fuel economy. It is in reality an account of the losses going on in the operation of steam boilers, whether due to furnace or any other causes. There are six principal losses discussed, but to only one of these losses is any relation attributed to the design of the furnace. The loss which is stated to be of the greatest importance, that due to excess of air over the quantity chemically required for perfect combustion, which is taken up at considerable length, is not attributed to furnace design, for the author states that the fireman is largely responsible for it.

3. The only loss I find here to which the title of "Furnace Design" is strictly applied is that headed "Unburned Gases." It is stated that to accomplish the combustion of these gases the furnace and boiler should be designed so that the heat will be generated in one and absorbed by the other. From statements further on I judge that, to provide for this division of the furnace and boiler, the author considers it necessary to use the Dutch oven principle, in which the furnace is entirely separate and wholly surrounded by brickwork. It would be interesting to know whether he has any other grounds for this conclusion than those mentioned or intimated. Does he think that the

economy of the return tubular boiler, on which the table of boiler losses given is based, would have been improved if it had been fitted with a Dutch-oven furnace? It would seem as though the loss of only 0.8 of 1 per cent., due to unburned gases which the table gives, represents the extent of the improvement possible, and that this is a very small inducement to change the ordinary type of furnace to the Dutch-oven system.

It would be interesting also to be informed in what manner he would apply the Dutch oven to the return tubular boiler mentioned, so as to make the saving noted, without increasing the loss due to the *radiation and absorption* of Item 7 to such an extent as to more than offset all gain which would result. My own opinion is that, if we liken the unburned gases to a disease and the Dutch-oven to a remedy, the remedy is worse than the disease.

4. The views of the author that the furnace should be separated from the boiler, are made even more pronounced by the statement that an internally fired boiler is the most extreme case of violating the laws governing economical combustion with bituminous coals. I hardly think this statement will be accepted unopposed by those who are most familiar with boiler engineering; and I would like to know whether the opinion here expressed is the result of actual tests of the author, or is it based on theory? I am sure the statement cannot refer to all types of internally fired boilers, for I have made tests on boilers of this kind and obtained fully as high efficiency as I have with an external furnace.

5. I would be glad if more data were given regarding the eighteen evaporative tests on the 200 h.p. return tubular boiler, such as duration, kind of coal, general conditions and objects, character of fire, capacity and flue temperature; also whether they represent average working conditions or test conditions. They can hardly represent the former, for the great majority of steam plants have more than a single 200 h.p. boiler, and the results obtained on a single boiler are hardly representative of those obtained on a plant as a whole. It seems to me also that they are not representative of the latter, for an efficiency of 66.7 per cent., which is here given, represents a low degree of economy for an ordinary evaporative test on a return tubular boiler. In a representative boiler of this kind, using coal that is not too high in volatile matter, there is no difficulty on such a test in obtaining 75 per cent. efficiency.

6. Nothing would be more interesting than to have the

author's ideas as to how, and to what extent, the various losses to which he refers can best be overcome and the efficiency improved. Referring to the second item of the table, would he have the fireman refrain from wetting the coal, and does he think that coal cannot be too dry for best economy? In Item 3, how would he reduce the loss due to the waste heat of the gases? Would he use a feed water heater in the flue? Would he preheat the air entering the ash pit by means of the waste heat of the flue? Would he endeavor to make the heating surface of the boiler more efficient? How would he change the design of the furnace, or that of the grate; or what would he do in regard to the relative dimensions of grate surface and heating surface? In the case of Item 4, what influence would he bring to bear upon the fireman to make him use air economically so as to prevent excess? Would he have the fireman carry the thickest fires possible in order to reduce this excess to a minimum, which might be inferred from one statement in the paper; or, if not, what thickness of fire would he recommend in order to get the proper proportions of air and combustible gas? Would he vary the air space in the grates for this purpose? Would he cut off altogether the air supply above the burning coal? Would he apply an automatic stoker to the furnace so as to secure the complete combustion that he intimates such a device gives, and overcome the loss noted in Item 5, or would he design some untried furnace to secure these results? Has he any method for reducing the loss in Item 6, due to unburned coal? What would he recommend for overcoming radiation losses from brick setting and otherwise, noted in the last item? In short, to what extent can these various losses be reduced in any specific case, like that to which the table applies, and what practical means can be adopted to secure the desired ends?

The Chairman (Mr. F. W. Dean). — That is the only written discussion presented on Mr. Bailey's paper. Before Mr. Bailey comments on Mr. Barrus' discussion, perhaps somebody else has something to say.

In regard to Mr. Bailey's fear that, with boilers of the vertical type, in consequence of the unburned gases striking the cold heating surface so quickly, the combustion will not be completed; you have in the case of the horizontal return tubular boiler the gases going up immediately against the cold bottom of the boiler, and in the case of many water tube boilers the gases going up between the tubes.

I might mention also that in Mr. Barrus' book on boiler

tests, the boiler that gives the highest evaporation is the Manning boiler with crown sheet less than 5 ft. above the grate. That would indicate that it is just as possible to have as good combustion in a fire box surrounded by water spaces as it is in any fire box.

In regard to smoke prevention, I think the most smokeless chimney that I have ever seen was one at the Lower Pacific Mills in Lawrence, when they had Galloway boilers, with furnaces that were, I think, 30 in. in diameter. Little or no smoke could be seen from the chimney, although the boilers were pushed much.

Mr. W. G. Starkweather. — What kind of coal were they burning?

The Chairman. — Such bituminous coal as we usually get here, probably Georges Creek Cumberland. In a furnace of that kind, if you let air through the door, you are pretty sure it will mix up with the gases. It can't do otherwise, in fact. The mixture must be pretty intimate, and if the temperature isn't lowered below the point of ignition, then I think the smoke difficulty is solved. Certainly it was in that case.

Mr. Starkweather. — What you say about vertical boilers is borne out by our experience. We have used vertical boilers for a good many years. They have shown high efficiency, but we run across the difficulty of keeping scale off the tube-sheets. The tubes of our boilers are in rows radiating from a front hand-hole of large size, so that you can clean the crown sheet between them.

I think the boiler proposition is the large one to-day. It is not so much the utilization of the steam after you have it, as it is the getting of it as cheaply and smokelessly as possible. Steam engines have about reached the apparent limit of their possible efficiency. Of the various boilers on the market — and there are many types — certainly the internally fired boiler, such as the marine, gives fairly good satisfaction and develops high efficiency. In the marine service, however, they usually burn a very high class coal, a short flaming coal so that combustion can be almost completed before the gases get back into the combustion chamber and strike the tubes.

I was very much interested in the percentages of losses, as stated in the paper, especially the amount due to air excess, to radiation and absorption, and to air leakage. I believe we do not usually realize the amount of loss that can come from these causes. The question of air leakage is a vital one. The amount that can get in through loose mortar and around clean-out doors

pipes and flues, is something remarkable, and is a constant loss. Ordinarily you can close up those leaks with fire-clay and asbestos, thereby increasing the economy considerably.

High temperature in the uptake is a similar loss, but easily controlled. Many times a large saving can be made by decreasing the grate surface, burning perhaps a larger amount per square foot on a smaller total area, thus intensifying combustion and creating better conditions for the boiler.

The question of distance of the shell of the horizontal return tubular boiler above the grate is another important one. Personally, I think it should be as much as available space will permit. The additional radiation due to the brickwork is, of course, a loss, but that is not very serious if the brickwork is properly constructed. But, on the other hand, you gain a large combustion space, in which the hot gases and air can intimately mix and have time to combine.

I recall one instance where we supplied two 72 and 18 horizontal return tubular boilers in which the masons made the setting 22 in. thick and solid. It was much too hot to bear your hand on it. The radiation loss in that installation was very high.

A test was made in Milwaukee last summer by a Chicago consulting engineer which was interesting. The boiler was used for heating purposes and had a down-draft furnace for the utilization of western coal of about 13,000 B.t.u. It was 16 by 60 and 87 h.p., and we carried 14 lb. pressure. The boiler was run at its rating, and developed an evaporation of 9.27 lb. of water per pound of coal as fired. That gave us an efficiency of 78.76, which is higher than some experts, as Professor Kent, think possible.

In this connection you are doubtless aware that the coals used in the Middle West are very poor — low in fixed carbon, and high in volatile and ash; and that is one reason for the smoke nuisance in the Middle West. The atmosphere of eastern cities is much cleaner than that of Chicago, St. Louis and Cincinnati, for instance.

Usually that coal is sold at about half the price of steam coal in New England, and with proper handling will, of course, make steam very cheaply. For instance, in this case, the cost was 13.50 cents per thousand pounds. It was burned without serious smoke. Of course, the rate per square foot of grate was very low, 5.96 lb. If the Rhode Island coal can be utilized in any way, it would cause a remarkable saving in New England.

That coal can be delivered, I understand, for a dollar a ton at the mine.

THE CHAIRMAN. — I think the only hope for that coal is in briquetting it.

MR. STARKWEATHER. — Perhaps it can be used in gas producers. Recent tests on it have shown carbon of from 65 to 80 per cent., volatile and moisture each 5 to 10 per cent., ash nearly 15 per cent., and less than 2 per cent. sulphur. No serious difficulty was found in generating a good gas in a producer, which apparently could be very effectively used in the gas engine as built to-day. This would materially reduce the cost of power for New England manufacturers, and there is a large quantity of it close at hand.

MR. E. P. SPARROW. — My observation of the work of the particular boilers to which you refer, Mr. Chairman, tends to confirm the opinion that as a rule large units give the most satisfactory results.

Mr. Bailey refers to the losses due to excess air. This is a matter of far more importance than generally supposed. Eliminating leaks into setting, flues, etc., is all that is necessary in many cases to transform an unsatisfactory into a fairly successful operating plant.

Generally speaking, there is an excess of air passing through the grate, and I am of the opinion that the percentage of CO_2 found in the escaping gases from the average furnace is from 6 to 8 per cent. only.

As a matter of fact, there is no way to determine how perfect combustion is in any furnace, except by an analysis of the escaping gases, and it is not likely that any improved design of furnace or method of burning coal will automatically control the air supply or eliminate the personal factor in firing.

It is possible for an observer to make an analysis for CO_2 only, once in five or ten minutes.

But to get at a fair average, and to plot a curve showing what is taking place in the furnace, requires that the percentage of CO_2 be determined at frequent intervals, for 10 or 24 hr., as the case may be.

An automatic CO_2 recorder will furnish the desired information regarding combustion, the value of individual firemen, as well as other interesting information, which is not to be satisfactorily secured in any other way.

Such an instrument requires very little attention daily, and will give results well within 1 per cent. of that obtained with

an Orsat apparatus under the same conditions, which is closer than the work of the best fireman.

To get the best results the instrument should be thoroughly understood and handled with the same care and intelligence usually accorded an Orsat apparatus; if it is looked upon and treated as an ordinary piece of boiler room equipment the results are quite likely to be unsatisfactory and misleading.

THE CHAIRMAN. — I think one thing ought to be done in boiler plants, and that is to make the owners realize the importance of teaching their firemen how to fire. There are some places where they have a CO_2 recorder and compel the firemen to watch it, and where that is done I have no doubt the firing is very much improved. Now to illustrate what good firing can do, I had a very instructive case some years ago. By improved firing the evaporation was raised from 8.34 lb. to 12.84 lb. of water from and at 212 degrees per pound of combustible.

MR. STARKWEATHER. — Mr. Chairman, what do you think of the bonus or premium system of firing for the man behind the gun in the boiler room?

THE CHAIRMAN. — In what way is it applied? I don't think I know just what you mean.

MR. STARKWEATHER. — I refer to the establishment of a certain evaporation per pound of coal as a basis, and for every pound the evaporation is increased over that the fireman is paid a certain extra amount. For instance, say that 9 lb. is fixed on as his rating, and that he is to receive as a bonus $1 a week for every pound or fraction that he beats 9 lb. That puts him beyond the CO_2 recorder. It is then a question of his ability to get the best out of the boiler, based on his daily work and study of the operating conditions.

THE CHAIRMAN. — I should think it would be a good thing, but I think the CO_2 recorder would be a good thing to aid him in doing that. In other words, the bonus would cause him to watch the CO_2 recorder and enable him to accomplish his object better.

MR. STARKWEATHER. — Usually a fireman, if of ordinary intelligence, can judge very closely of the conditions under which his boilers are running from the way in which the coal is fired, and oftentimes is much better informed on his particular plant than any one else. Unfortunately, these men are ordinarily without education and know very little of the reasons for the various changes that go on in the boiler or the real effect of changes in conditions; but they do know how much coal they

fire and whether "she steams easier or harder," as they say. And they find ways of cutting down the air supply, increasing the draft or checking it, etc., to save labor for themselves. They are not interested so much in the coal as in their own labor. I think the fireman is a much neglected quantity in the boiler problem.

MR. B. R. T. COLLINS. — I tried the bonus system in Chicago about ten years ago when I was in charge of the Harrison Street Station of the Chicago Edison Company. We had a CO_2 recorder and hot water meters installed in connection with all of the boilers, and I thought I would see what would happen if I offered a bonus for the best work. So I offered $2 a week extra to the fireman who made the best evaporative record combined with the best record with the CO_2 recorder. The men worked harder for that extra $2 a week than they ever worked before. It was remarkable to notice the increased efficiency of the station. I kept this up for six or eight months, and found that the effect of this system on the economy of the plant amounted to an increase in efficiency of between 10 per cent. and 15 per cent. In connection with the CO_2 recorder we had a pipe header with cocks arranged so that flue gas samples could be taken from any one of twenty-four boilers, and at night we would leave the recorder connected to one of the boilers and lock up the pipe header case so that the firemen would not know from which boiler the gas was being taken. The firemen, after firing each boiler carefully in turn, soon found out which one the recorder was connected to, and then the man in charge of that boiler would fire carefully and the others would do as they pleased. So it didn't work out at night as well as in the daytime when we changed the recorder from boiler to boiler at short intervals.

I also tried dividing the firemen into two classes. The firemen whose records in evaporation and CO_2 percentage were above the average were rated as first-class firemen. The men who were below the average were rated as second-class firemen. The pay of a first-class man was $2 per day and of a second-class man $1.89. A list of the two classes was posted every week, with the understanding that the man at the top of the first class would be the first to be promoted to a better job, while the man at the bottom of the second class would be the first to be discharged. This worked all right for a month or so. But one night when the peak of the load was on and we were carrying about 18 000 h.p., they all threw down their shovels and went out. I asked what the matter was and they said, "We don't

like this first- and second-class fireman business. We think we are all first-class firemen." I said, "You go back to work and I'll think it over." I thought it over for a week and abolished that system.

I want to ask the chairman a question as to his experience in the prevention of smoke with the ordinary B. & W. boiler setting. My experience has been that it is very hard to get smokeless combustion with such a setting. Have you had any experience with any special furnace arrangement for preventing smoke with the B. & W. type of boiler?

The Chairman. — No, I never had. My experience has been with the ordinary arrangement of furnace that is usually put up.

Mr. Collins. — There is generally a considerable amount of smoke with that setting when used with soft coal.

Mr. Bailey. — I have seen a B. & W. boiler set with a Dutch oven furnace that, with careful firing, was practically smokeless. I understand that at the Chicago-Edison plant they have an arrangement similar to what was put on the H—— boilers at St. Louis during the government test, and they claim absolute smokelessness from this in the Chicago-Edison plant. It carries the flue gases clear to the back end of the tubes under a firebrick arch which is composed of tile on the bottom of those tubes and then passes the gases right back in the opposite direction.

Mr. Collins. — I tried this arrangement about ten years ago at the Harrison Street station of the Chicago-Edison Company, and it worked out nicely on the H—— boiler. It amounted to a firebrick arch 13 ft. long over the grate and combustion chamber back of the bridge wall. The gases did not touch the tubes at all until they had traveled 13 ft. under this brick arch. This was with the H—— boiler, but I understand that it is being adapted to the B. & W. boiler.

Mr. Bailey. — I have never had an experience with that particular setting, but with the Dutch oven, hand-fired, it can be run practically smokelessly, with about an 8-ft. combustion arch, over a 5-ft. grate and a 107 h.p. boiler.

I think Mr. Barrus' discussion was much more premeditated than my original paper. I admit the fault of not adhering to my subject for one thing. The subject was given by me and several weeks elapsed before I realized I had to talk, and the talk being off-hand, I naturally strayed some.

Mr. Barrus takes up the matter pretty much in detail, and,

as he says, the data, and in fact the whole paper, was based on personal observations. Some of them had not been given a great deal of consideration since the results were taken, and oftentimes there was no chance to follow up with one plant and see just what could be obtained in the way of increasing the efficiency or changing the conditions. With regard to a good deal of his discussion, especially where he asks for more complete data in regard to the boiler plant on which that heat balance is shown, I will look up further data and answer specific questions of that character more definitely than I can to-night.

The heat balance given was the result of eighteen tests made on one boiler out of several similar boilers. It was due to the difficulty in weighing water for such a large plant that the one boiler only was used for these tests, the object of which was the comparison of different kinds of coal. The coals used ranged from 12 800 B.t.u. up to 14 400 B.t.u. as I remember it. Some of the coal was very high in sulphur and very high in ash. The firing was done by the regular fireman. He had another boiler to attend to in addition to this one, and he paid absolutely no attention to the test. He didn't care whether the CO_2 was 5 or 15. He wasn't given one word of instruction throughout the eighteen tests. The idea was simply to see what could be done under actual working conditions with the various coals. I will give more specific data as to the air excess and flue temperatures when I have the figures available. But the one interesting point from this number of tests was that throughout that range of ash, a considerable range in the amount of clinker formed, and the range of calorific value, the boiler efficiency did not vary but about 2 per cent. between the 12 800 B.t.u. and the 14 400 B.t.u. A secondary object of these tests was to see how closely the chemical analysis and the B.t.u. compared with the actual boiler results. Some people are skeptical about laboratory results because they are not practical. What they want, they claim, is coal that will evaporate the most water per dollar. That is true. That is what everybody wants for the steam coal. They consider chemical or laboratory results are all theoretical and far from reliable. But a review of the locomotive tests made by the Pennsylvania railroad at St. Louis, and also of those made by the United States Geological Survey at St. Louis, where they are conducted under as nearly the same conditions as possible, so far as the boiler is concerned, will almost knock the faith in boiler tests out of any one. The results are apparently up and down with no accountable reason.

In trying to derive useful information from the four hundred boiler tests, Professor Breckenridge has recently published "A Study of Four Hundred Steaming Tests." It is noted that many of the curves do not fall in any regular line. As many as five to forty different tests are averaged for one point on the curve. If each one of those tests was taken individually and plotted on coördinate paper, it would simply be one mass of spots. And it is only by averaging up all the variations that enter into each individual test that any plausible rules governing the efficiency, or the completeness of combustion as being affected by air excess, or the kind of coal, or the percentage of ash and the various classifications given, can be laid down; and it is really discouraging for any one who has been accustomed to depend a great deal on one single test.

As Mr. Dean just mentioned, in his tests at Lynn there was a variation of practically 100 per cent. between the first test and the last. So that if the fireman or the condition of the grate can affect the test by 100 per cent., it seems as if it would be a difficult matter to determine the relative value of two coals within less than 5 per cent., and 1 per cent. may mean thousands of dollars per year in the efficiency of the boiler. One person can prove conclusively that the internally fired boiler will give, say, 75 per cent. efficiency. In another case it may give 50 per cent. The Dutch oven may give 50 per cent. in one case and 75 in another. There are so many other conditions that enter in. It is very difficult really to tell what is the most economical coal from evaporative tests alone, or what is the most economical furnace or boiler setting. And it is only by a series of tests, where the average will eliminate the minor variations, that any reliable results can be obtained.

Now, as to the question of internally fired versus the Dutch-oven type. As I have just said, it is hard to prove conclusively in any particular case or set of cases that one furnace is superior to another. But in every series of boiler tests in which I have had occasion to plot out the results and try to learn something of the laws governing the efficiency, I find that the radiation of undetermined loss always increases as the percentage of CO, and generally with the rate of combustion. And in this test here the loss of 0.8 per cent. of unburned gases should read, "loss due to CO," because the heat due to the escape of carbon in the form of smoke and hydrocarbons present was not determined, as the Orsat apparatus was used. And every test, or series of tests, points to that one factor — that there are gases escaping un-

burned that are never determined, and the only way they show up in the heat balance is by measuring radiation or undetermined loss. And this loss does increase very decidedly as the CO increases with the ordinary flue gas analysis.

The Pennsylvania Railroad locomotive tests at St. Louis were made on eight different engines. Six of these boilers had a firebrick arch. Two of them had not. I can't give the exact figure, but the per cent. of loss due to CO alone was as high as 16 per cent. in some of those cases where there was no firebrick arch in the fire box. It seldom exceeded 3 or 4 per cent. to my recollection, in the furnaces where there was a firebrick arch. And the average of all the tests with the firebrick arch and of those without showed a decided difference which nobody can question. And there was evidently no reason for this difference in the CO loss, except the firebrick arch. In all cases, the rate of combustion varied from very low to extremely high, and the loss due to CO increases proportionately to the rate at which the boilers were forced.

Mr. Bement, of Chicago, and several of the engineers who have got to solve the smoke problem in the West, all point to the fact that the combustion cannot be completed in a short distance. A firebrick arch covering the combustion chamber and some method of mixing the gases must be used, or not only smoke, but unburned hydrocarbons, will escape. And as to the question of unburned gases, the practical fireman can tell you a great deal. When he gets the unburned gases afire in his smoke connections or in his stack, he will see the flames issuing from the stack or funnel, as I have seen them on a steamboat burning north England gas coal, containing over 30 per cent. volatile matter, in Scotch marine boilers. When the fireman put in a good fire, and by a spark or some means the unburned gases issuing from that stack together with the dense black smoke caught fire, immediately the flame sprang out of that 8-ft. funnel and shot into the air 10 to 20 ft. There wasn't a particle of smoke issuing from the top of that flame. The combustion was complete, but the temperature of the unburned gases was somewhere in the neighborhood of 1 500 degrees fahr. . . . So if you take into account all unburned hydrocarbons, you will still have the same boiler efficiency. The loss occurs just the same. Not later than yesterday I saw in a return tubular boiler where the combustible gases were going through the flues in such quantities and at such temperature that the opening of the uptake doors caused the gases to ignite and the smoke connection

was raised to a bright heat in a short time. I have seen that repeated time and time again. I have seen several pyrometers broken by being heated to the temperature resulting from the burning of those waste gases. Now, while there is no evaporative test going to show what this amounts to through a period of 10 hr. when the fireman is on his guard, yet if we did have not only CO_2 recorders, but CO and hydrocarbon recorders, we should find in the average day that this loss was a tremendous quantity in certain boiler installations.

The question of air excess in connection with these unburned gases is very interesting, and especially the infiltration of air through the brickwork. These two losses come inversely to each other, as a rule. With high air excess your unburned gases are low. As you reduce your air excess, you increase the possibility of unburned gases escaping. So that there is a happy medium in between, where you have the same loss due to each, and the sum of the two is the minimum. One disadvantage of the CO_2 recorders is the tendency on the part of the fireman to try to get too much CO_2. There is very little gain in economy after it reaches 12 per cent., because each per cent. of CO_2 then means not more than 6 to 10 per cent. air excess, while in the neighborhood of 5 or 6 per cent. of CO_2 it means about 50 per cent. of air excess for each per cent. of CO_2. So that when a man tries to keep his CO_2 extremely high, the loss due to unburned gases increases and oftentimes more than counteracts the saving which he has made by reducing the air excess. For instance, in a large power plant, before they put in CO_2 recorders, the CO_2 ran between 7 and 8 per cent. And when the fireman was watching the machine and doing his best, it ran up to 14 or 15. The CO and hydrocarbons were not determined, and had they been the loss due to them would probably have counteracted, or even more than counteracted, the difference in saving they would have made if they had only attempted to keep the CO_2 at about 10 or 11 per cent. A leakage of air through the brickwork is one of the most interesting things, I believe, that any man with an Orsat apparatus runs into. The clean-out doors need only be left open a quarter of an inch, and a little half-inch crack here or there to let as much air through the boiler setting as is going through the grate. The flue temperatures are often found to be below the temperature of the water in the boiler. There must be some cooling action or this could not occur, and the analysis of the flue gas generally shows where the trouble is. Speaking of the air spaces in the boiler setting reminded me of

a plant of return tubular boilers where, in order to prevent the cracking of the brickwork, some half-inch pipes were put in through the outer wall leading into the air space. By means of these holes it was very easy to measure the draft in this air space. And with the 0.6-in. draft over the fire we measured about 0.3 in. draft in the air space. There were several half-inch pipes supplying air into this air space, and still the vacuum maintained was half that of the furnace. The inner lining, which was solid showed a large amount of air was leaking through the porous brickwork and mortar.

Another case where we analyzed the gas in a 350 h.p. B. & W. boiler, we took one sample within 20 in. of the inside wall, where two boilers were set in battery, and another sample within 20 in. of the outside of the boiler wall, we found the air excess to be 180 and 205 per cent., respectively, in the two cases.

The question of smoke is one that everybody claims is not a serious loss. They figure 1 per cent. as covering the real loss of carbon particles. That is a figure that seems to be in every body's mind, and nobody seems to know who determined it, where the figure came from, or how authoritative it is. But even if this loss is only 1 per cent. the public sentiment is such that this problem must receive consideration. And I believe that in Boston there is less of an attempt to solve this problem on a real scientific basis than there is in many other places. In Germany and England it has been found that a fine is not sufficient to prevent this nuisance. So societies have been organized that have gotten the scientific, the practical and the financial men together in the hope of finding a remedy for this smoke problem and preventing it by scientific and practical methods. And from what I can learn, they are meeting with much more success than we are in many parts of the United States. I recently read a report of a committee of the city of Syracuse on smoke prevention, and I think it will pay any one to read that report simply for the literature and information collected on the subject, and for the scientific and practical way in which the subject has been handled. It seems that here in Boston there is no particular standard for smoke. There is a law that specifies that dense or dark gray smoke shall not issue from a stack longer than six minutes during an hour. And the question is, What is dense or dark gray smoke? No two people can agree on it, and there seems to be great difficulty in determining what density of smoke comes within the law and what does not. The man who owns the plant is very backward about paying any fancy

wages to his firemen. He claims he is paying as much as the next man and that his firemen are as good as any.

The Chairman. — Excuse me for interrupting, but this Syracuse report is issued by the Chamber of Commerce, isn't it?

Mr. Bailey. — I think it is; yes.

The Chairman. — I think, unless they are all gone, anybody can get one of these reports by writing to the Chamber of Commerce for it.

Mr. Bailey. — I am sure he can. I will just speak a few words further in regard to the heat balance. As Mr. Barrus has said, evaporative efficiency of such a boiler should be 75 per cent. In looking over the losses, the first is the latent heat, which is impossible to reduce. Had these heat balances been figured on combustible or dry coals as a basis, the efficiency would have been higher. But for several reasons I think results based on dry coal and combustibles are misleading, because what a man burns is actually wet coal — not exactly wet, but containing moisture. And all the results a practical man cares for are results based on coal at the price he pays for it. And it may be that Mr. Barrus is confusing this heat balance with one based on combustible.

The loss due to products of combustion is a function of temperature, and loss due to air excess is both temperature and the amount of air passing through the fire. The latter could probably be reduced to 3 per cent. under the best of conditions. That would save 5.5 per cent., which would throw the boiler efficiency up to 72.2 per cent. And unburned CO might increase it to 73 per cent. The only other place to recover loss in the heat balance as given would be in unburned coal, and it is seldom that this loss is lower than the figure here given, as it is unusual to find refuse that contains less than 20 to 25 per cent. of combustible in it. In most plants the principal thing that the fireman has to do is to keep steam. And in order to keep steam on a given boiler grate surface, he has got to keep the ash and clinker off his grates. It is much more important to do this and maintain steam pressure on a minimum number of boilers than it is to save a possible half of one per cent. due to loss of unburned carbon. A thing that frequently comes to my notice is that in cleaning fires the fireman will sometimes let his fire burn down to a very black grate — nothing but ashes and clinkers. The cold air passing through the bare grate probably carries away ten times as much heat as would have been lost if the fireman had pulled out a small amount of unburned carbon. Unburned

carbon is something he can see. Air excess is something nobody sees.

Loss due to radiation and absorption. This on any type of boiler is impossible to reduce, unless it contains, as I previously said I believed it did, some loss due to unburned gases. The amount that this loss should be is a considerably mooted question. Professor Kent seems to think it ought to be in the neighborhood of 4 or 5 per cent. Other tests show it as high as 12 or occasionally 15 per cent. When a person considers that this loss includes not only the loss, but all the errors in determining the average heat value of the coal fired and the average air excess, and when you consider the velocity of the air, changing from time to time to different parts of the flue, and the amount of unburned gases, especially of hydrocarbons, which are exceedingly high in calorific value, it is not at all surprising that this value should vary considerably.

On a set of locomotive road tests that I once assisted in, we found our heat balances checked up and left not more than 2 or 3 per cent. of loss due to radiation. This, of course, was where your rate of combustion was exceedingly high and your B.t.u. loss in radiation was figured on a very large basis. If that boiler had been run at the ordinary rate that is usual in stationary practice, the same number of heat units would probably have been radiated per hour, and it would have made considerable difference in the percentage of total heat being generated. The locomotive tests at St. Louis, unfortunately, did not go into the boiler part of it sufficiently far to show the heat balance. But in figuring out some of them I find that the radiation loss varies from a minus quantity to plus 20. And this is partially due to our inability to determine the amount of unburned gases as well as unburned carbon which was passing out of the stack. In each case they found it to be about 8 per cent., and then they found sufficient carbon lying around to give them ground for practically doubling it. On these other locomotive tests I referred to, they determined this loss of unburned carbon passing out of the stack by taking a sample of coal and determining from the weight of the coal the percentage of ash or the total amount of ash that was fired into the fire box. From the weight and analysis of refuse taken out of the ash pan, the total amount of ash falling into the pan was determined. Then by collecting a sample of the cinders and sparks passing out of the stack they determined the percentage of ash in that, and knowing the weight of ash passing through the tubes by difference, they were able to figure

the total weight of sparks passing out of the stack. In every case, the test running 72 miles, this loss amounted to 15 or 20 per cent., and over 2 000 lb. of sparks were thrown out of that stack for every test. I was very much interested, in view of these figures, in reading in the paper the other day about a cinder, spark and smoke observer riding on a Boston & Maine engine. He had a few ounces of cinders as a sample; and the newspaper correspondent said what a wonderful thing it was to collect them in a little tin can rather than to spread it out over the passengers. A tin canful of sparks in comparison with 2 000 lb. in 72 miles shows clearly how the newspaper correspondent comprehends the difficulties in complete combustion and general boiler work. I don't know that I have covered every point, but it is getting late and it is rather difficult to think of all the things mentioned by Mr. Barrus in this short time.

Mr. Bailey (*by letter*). — Further replying to paragraphs 3 and 4 of Mr. Barrus' discussion, I do not want to be misunderstood as stating that all bituminous or semi-bituminous coal should be burned in a Dutch-oven furnace, nor that no internally fired boilers are running with a fair percentage of efficiency. But for smokeless and complete combustion, the combustible gases must not be cooled below the ignition temperature before they are brought in contact with oxygen. In some boilers, internally fired or otherwise, the remedy of change in furnace design might be worse than the disease, depending upon the rate of combustion, method of firing, kind of coal, smoke restrictions, etc., but that there is more possibility of incomplete combustion in cases where heat is being absorbed at the same time it is being generated cannot be questioned. I have recently had occasion to analyze gases from an internally fired boiler, using not only the Orsat apparatus, but also the Hempel, and the hydrogen and hydrocarbons were determined as well as the gases usually included in the analysis.

A few analyses are given to show that an appreciable percentage of CO and CH_4 may be found in the presence of enough oxygen to have completely burned them had they not been cooled below the ignition temperature before the small percentage of oxygen came in contact with the small percentage of combustible gas. Take the case of sample 9, Test M, with 3.7 per cent. oxygen and 1.5 per cent. CO; the CO should have had 0.75 per cent. more of oxygen to have completely burned it. The oxygen present was five times as much as the CO required, but these two gases were diluted with about 95 per cent. of nitrogen,

carbon dioxide and water vapor. They were traveling at about 25 ft. per second through an average distance of about 4 ft. from the bed of fuel to the entrance to the tubes, thus giving about one sixth of a second for the CO and oxygen to find each other among 95 per cent. of inert gas.

The following gas analyses are by volume:

Test.	Sample.	CO_2.	O.	CO.	CH_4.	N.	Air Excess.
M	9	14.4	3.7	1.5	....	80.4	21%
M	10	13.3	2.1	6.2	0.9	77.5	11
M	Average all,	11.34	6.73	1.71	0.32	79.90	48
P	6	13.3	0.3	7.2	1.25	77.95	1.5
P	7	11.4	7.0	0.9	....	80.7	50.0
P	Average all,	11.88	5.80	1.97	0.40	79.95	38.0

Test.	Sample.	Air Excess if all Oxygen had been used.	Loss due to Air Excess.	Loss due to CO.	Loss due to CH_4.	Loss due to Unburned Gases.
M	9	16%	2.1%	4.7%	...%	4.7%
M	10	—17	1.0	19.4	8.4	27.8
M	Average all,	32	5.2	6.6	3.7	10.3
P	6	—43%	0.1%	21.8%	9.1%	30.9%
P	7	45	5.4	3.7	...	3.7
P	Average all,	23	4.1	7.3	4.4	11.7

Not only do the analyses show that free oxygen may occur with combustible gases, but from the two samples 9 and 10 in Test M, and 6 and 7 in Test P, we see that the gases coming through one set of tubes are entirely different from those coming through other tubes at the same time, as these two sets of samples represent such conditions. The average loss due to unburned CO and CH_4 is greater than the entire radiation loss from a Dutch-oven furnace and brick boiler setting. It would seem that in this case it would pay to apply some remedy. I believe that a more careful investigation of the composition of the flue gases would show a chance to make a great increase in the average yearly efficiency of many boiler plants. It may be possible to obtain a very satisfactory efficiency from any boiler when properly fired for a few hours during an evaporation test, but in order to economize in the annual fuel bill you must eliminate the possibility of a fireman wasting coal when you are not conducting evaporative tests or carefully supervising his work.

Referring to paragraph 5 I will give some additional data regarding the general condition of the tests referred to, more than has been given in the fore part of this discussion. The kind of coal was variable, the volatile ranged from 15 to 31 per cent.

The boiler was hand-fired, by the alternate method, and the bed of fuel was about 10 to 12 in. thick. The load was very uniform at about 30 per cent. above rated capacity. The flue temperature was about 490 degrees fahr., and the air excess was about 110 per cent.

How and to what extent the various losses of a steam boiler heat balance may be reduced and still have a net saving is a question that cannot be answered the same way in different cases. In many plants it pays to heat the feed water in economizers, while others have so much waste steam that the per cent. gain due to heating the feed water by the flue gases would not pay for the installation and maintenance of economizers.

No specific method of reducing the losses can be equally well applied to all plants, as the conditions vary so greatly with reference to kind of coal, uniformity of load, size of plant, character of labor available, etc.

Complete combustion of fuel with least possible amount of excess air is of primary importance in every case. It is of equal importance to absorb a large percentage of the heat developed by means of clean boiler heating surface, rightly proportioned to the amount of coal burned.

The most economical thickness of fire depends upon the kind of coal and intensity of draft, as well as the method of firing. Sometimes you will get the best results with a 4-in. fire, while with another coal and the same draft a 10-in. fire may be required.

As to mechanical stokers or other boiler room appliances, it is of common occurrence to see one plant discarding that for which another is placing repeat orders; and the reason why one plant found the apparatus a paying investment and the other considered it as a loss is very often traceable to the personnel of the boiler room labor and management rather than to the apparatus itself.

Mr. Francis H. Boyer (*by letter*). — We are under obligations to Mr. Bailey for his carefully prepared paper. The demands made in all our large cities and towns that boilers shall be so constructed and operated as to prevent smoke in any large amount being discharged into the atmosphere is surely a great stride for perfected combustion of coal and, therefore, economy in cost of operation.

Much of the fault of smoky fires from boiler setting is caused by the boiler being set too close to the fire. The distillation of gases from coal begins at quite a low temperature, from 150 to

200 degrees, depending on its quality. At this point atmosphere must be introduced into the coal gas; and when a temperature of approximately 500 degrees is reached by the combination of gas and atmosphere, the combustion becomes a fact, and the intense heat from 1 000 to 2 500 degrees takes place. In contact with the shell of the boiler, which at 100 lb. steam pressure per sq. in. is 312 degrees fahr., the combination of coal gas and atmosphere is rapidly cooled and will necessarily have to undergo a heating process before the combustion is complete. If this does not take place, then the combination of gases escapes to the atmosphere a black mass of smoke, or adheres to the shell of the boiler or tubes or brickwork as unburned soot or carbon to again be consumed when the heat reaches the proper temperature for combustion.

It follows that in setting boilers it is a good rule that works well, to set the boilers a long distance from the fires. This can be best seen in manufacturing plants where large fires are in use for heating metals or closed fire boxes. For instance, in a large forge shop, we often find boilers consisting of a shell, 72 in. in diameter and 20 ft. long, filled with tubes and set on end, at a distance from 30 to 75 ft. from the fire, or, if horizontal, encased in brick and placed up in the roof or walls of the building 30 to 75 ft. distant. The combustion of gases from these fires is complete before it reaches the boiler, and only the heated gases convey the heat to the surface of our steam boiler.

The placing of boilers away from the fires a distance such as to positively permit the combustion of the gases and allow only the heated refuse to deliver the heat, is in the line both of perfect combustion and of economy in fuel. This is well illustrated in the Dutch-oven construction. Many devices have been introduced to produce this result; one, by Dr. A. E. Kent, of Cornell University, consists of placing columns or structures of fire tile in the fire, which at all times is of a temperature sufficient to heat the entering gas enough to produce combustion.

In Mr. Bailey's paper he has shown up the proper condition when he describes the ore smelter in Michigan. After giving the size, he says that he has often seen from 80 to 100 shovels of coal thrown in the furnace at one firing, the furnace and smelting pan being only separated by a bridge wall in which a temperature of 2 400 degrees, approximately, was maintained.

Mr. Bailey does not tell us whether the air, forced through the fire or over the bridge wall without passing through the fire, was heated before entering or not. It is safe to say that it was

so heated. This is the ideal condition for complete combustion as no surface presents itself for cooling the gases before the complete combustion is made.

A good story of Mr. ——, who installed the electric plant at Berlin in or about 1895 or '96 for the New York, New Haven & Hartford Railroad for the service of their experimental electric road between Berlin and Hartford, is told as follows:

The foundation for the boiler was complete (horizontal tubular pattern). The boilers were in place and blocked up, the walls were about to the lugs, with the usual 30-in. clearance between the grate and the shell of the boilers. After inspection, Mr. —— ordered the boilers raised 4 ft. from the grate to the shell, and gave orders to notify him when the brickwork was up to the lugs. After the second inspection, he ordered the boilers raised another 4 ft., or a distance of 8 ft. from the grate to the shell, and the mason work was completed. It was the privilege of the writer to visit this steam plant at Berlin at the time of the American Society of Mechanical Engineers' meeting in Hartford in 1897, and the working of the boilers was satisfactory, with no smoke from the furnaces and to all appearances complete combustion.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 1, 1908, for publication in a subsequent number of the JOURNAL.]

ECONOMICAL LUBRICATION OF LARGE PLANTS.

By William M. Davis, Member Engineers' Society of Western Pennsylvania.

[Read before the Boston Society of Civil Engineers, December 18, 1907.]

In the lubrication of a large plant the first consideration is, of course, efficiency, then economy, although some engineers seem to think that it is impossible to attain the first and at the same time give any consideration to the latter.

To obtain efficient lubrication the most important thing is to know that the lubricants used are of good quality, either by choosing well-known or tested brands, or specifying what they shall be composed of and to what tests they shall conform. Next, see that suitable and reliable appliances are provided for feeding the oils, that the crank-pins, eccentrics, bearings, etc., be provided with center oilers and sight-feed cups, so that every drop of oil will go directly to the bearing surfaces without any being thrown or spattered over the engines or machinery.

For slow-speed engines, ordinary sight-feed cups, properly looked after, will give satisfactory results, but for heavy high-speed work a continuous oiling system, with the oil flowing from an overhead tank to the bearings, in streams if necessary, thence through a filter and back to the overhead tank, is the most efficient method of lubrication. From an economic standpoint, however, the success of such a system will depend entirely upon the means provided to catch the oil after it leaves the bearings.

With slow-speed engines, and in fact with all machinery that uses oil in quantities, every bearing on which oil is used should be provided with substantial sheet-steel pans, arranged, if possible, to drain the oil to some central point into a bucket or tank, from which it can be taken to the filter. If the engine is of the horizontal crank case type, care should be taken to keep the oil as free from water as possible, as water will sometimes travel along the piston rod into the crank case, and, if it is the least bit alkaline, as may be the case where compounds are used in the boilers, the oil and water together will sometimes form an emulsion which is hard to separate and lowers the quality of the oil. The above would not apply, of course, to the vertical type, such as the Westinghouse steam engine, which uses water in the crank case.

To secure economical lubrication, the first thing to do is to stop the leaks. See that every engine and piece of machinery is provided with drip pans arranged so as to catch all the oil. In a large plant where several engines are in close proximity to one another, the oil pans may be piped so as to drain the oil into a central tank, whence it can be pumped to the filter and used over again. On slow-running engines where the pressure is not excessive, and on slow-running shafting, a good grade of grease or tallow compound will often give good results, but where compression cups are used the grease should be quite soft so that it will spread freely. If too hard, great pressure will be required to feed it, and it will also tend to increase the friction load.

With large engines it is sometimes the case that the hub of the fly-wheel or a large gear wheel is fitted so close to the bearing that there is not sufficient space to fasten oil pans under the bearing, and all excess of oil will be lost. Such bearings can often be lubricated economically by packing a lump of medium hard grease on the journal, at each end of the bearing, and feeding a little oil in the middle. The grease will prevent the oil from running out too fast, and at the same time help to lubricate.

In regard to cylinder lubrication, no one can make any hard-and-fast rule as to the proper amount of cylinder oil that should be used; that will have to be determined by test and experiment. First, a good quality of oil should be provided. Second, to get economical results, make the conditions as favorable as possible. See that the steam is dry; do not carry the water in the boilers too high; do not use an excess of strong alkaline boiler compounds; and above all, do not set the piston rings out too tight. Before putting the rings in the piston, chamfer the edges off slightly with a file, for if the edges are sharp they will tend to scrape the oil off the surface.

From the lubricator the discharge pipe should extend into the center of the steam pipe, so that the oil will drop off into the current of steam. Where the engine speed is constant, there is little choice between a force-feed pump and an ordinary sight-feed lubricator. Either will give efficient and economical service if properly taken care of, but where the work is intermittent, the engine stopping and starting, as is the case with mining engines, tug-boats, etc., the force-feed pump is more economical.

To determine the proper amount of cylinder oil to use in any particular engine, first have the conditions as favorable as pos-

sible. Then gradually reduce the oil feed and note the ac ion of the valves. If they work smoothly, it is a good indication that the cylinder is all right, but if they commence to groan, increase the oil-feed slightly. In this way the minimum amount of oil that should be fed can be determined very closely. After this the cylinder head should be removed and the surface of the cylinder examined. If it looks oily, and when wiped with a piece of soft paper a stain is left on the paper, it is certain that enough oil is being used.

Another important matter in economical lubrication is in the receiving, handling and proper distribution of the lubricants. If the plant is a large one, the oil house should be provided with storage tanks of sufficient size to hold a tank car of each kind of oil. By purchasing the oil in tank cars there will be a reduction in the price per gallon and a saving in the labor of handling of the oil and the empty barrels. In a small plant where only a few barrels of each kind of oil are used a month, tanks holding from 2 to 10 barrels should be provided, so arranged that the oil can flow by gravity from the barrels into the tanks. Care should be taken to see that the barrels drain out clean.

As the empty barrels are worth from 50 cents to a dollar each, they are worth saving, and should be piled up in a cool, dry place until a sufficient number have been accumulated to make a carload. Before being loaded into the car for shipment back to the works, the hoops should be driven up tight so that there will be no danger of their coming apart and the barrels falling to pieces. The credit for the empties is based on their condition on arrival at the barreling station, and the amount paid is quite an item in reducing the lubricating cost.

It is customary in a large plant to have in charge of the oil house a man who receives and stores all lubricants, issues and charges them up to the various departments, keeping a record of the amounts given out in a book or on suitable blank forms. There are two good methods for limiting the daily amount of lubricants for each department. One is for the chief engineer or master mechanic, when making his daily rounds, to give each engineer an order for his day's supply of oil and grease. In this way he knows if the amounts required are increasing or decreasing. Another is to draw up an allowance sheet showing the amount that each engine room or department can have per day or week with the proviso that if, for any reason, it is necessary to have more than the regular allowance, a written order must be presented to the man in charge of the oil house or the storekeeper.

In a small plant the storekeeper often has charge of the oil house, opening it for half an hour in the forenoon and half an hour in the afternoon, so that those who need lubricants can come or send for them during these times. At the end of the month the storekeeper totals up the amounts of lubricants used in each department and engine room on special blank forms, and these amounts, when multiplied by the price per gallon or pound, will show the total cost for lubricants for the month. By this means it will be shown if the cost is increasing or decreasing in any particular department.

It has been found to be an excellent plan to give the engineers and heads of departments a copy showing not only their own consumption and costs, but the cost of the other engine rooms. This tends to establish a rivalry among the men, each trying to improve his practice and reduce the cost. It also tends to prevent them from wasting their supplies.

Reduction of Cost.

It is unquestionably true that nearly all plants spend far more than is needed for lubrication. This is due partly to wasteful methods in their use, partly from using lubricants unsuitable for the purpose required, and often to paying higher prices than is necessary.

The first mentioned can be prevented in a great degree by the introduction of systematic methods of issuing the lubricants and charging them to the different departments so that one can tell just what each engine room and department is costing and note if the cost is increasing or decreasing, by the introduction of more economical appliances, equipping the engines with pans and filters for recovering the waste oil, by self-oiling bearings for all line and counter shafting, etc.

In regard to more suitable lubricants, we will say that in many plants there is often a large amount of slow-speed machinery, on which, owing to its construction, it is not practicable to recover any of the oil used, in which case a good grade of what is known as dark lubricating or black oil will often answer as well as the more expensive oils. As illustrative of this, we have in mind a works that was using large quantities of an expensive grade of cylinder oil on its machinery where a heavy machine oil would have answered equally as well. In this particular case a saving could be effected amounting to over $2 000 a year.

Most important of all is to be able to purchase good lubricants at the lowest prices.

This can only be done with any degree of satisfaction by buying on specifications, submitting copies to several oil dealers, asking for bids and awarding a contract for a year's supply to the lowest responsible bidder. Of course we know that it is the practice of some oil companies to decry the use of specifications. One might as well expect the manufacturers of steel rails or cements, or the builders of engines and boilers to make the same claim as regards their products, or architects and contractors in regard to the construction of buildings. On the contrary, there is not a steel concern, cement works, engine builder or firm of engineers in the country to-day who would make such a claim. In regard to specifications, the writer will say that he has had about five years' experience with them, first while oil inspector for a large steel company operating about forty large mills, and also with many paper mills and other manufacturing companies in the New England states during the past year, and he has never known of a case where such oils have failed to give perfect satisfaction. Take the case of cylinder oils. For many years the oil dealers who sold their trademark brands at fancy prices fostered a belief among superintendents and engineers, amounting in some cases almost to a superstition, that there was something especially intricate or mysterious about the manufacture of cylinder oil, and if a consumer would have the temerity to use a cheaper grade of oil that he would encounter all sorts of trouble, cut and scored cylinders, etc.; while the fact is there is nothing to any cylinder oil except a petroleum cylinder stock of the proper quality compounded with a certain amount of some fatty oil. In the matter of engine and machinery oils, spindle oils, etc., it is simply a matter of knowing the conditions and requirements in a plant and drawing up specifications for such oils as will fulfill these requirements.

Grease.

Greases have their uses and can often be used with good economy, but, on the other hand, they also have their limitations as lubricants. Where the speeds and pressure are low, if they are of the proper consistency and fed to the bearings by suitable compression cups, they often give excellent results.

Greases are what is known as "plastic lubricants"; their particles have far less tendency to free movement than is the case with oils.

Many greases have as their base a petroleum oil combined with some animal fat, the whole solidified by combining them

with a solution of caustic soda, lime water or other alkalies, making a plastic compound that will vary in its lubricating value according to the proportions and the quality of its component parts. While greases have certain advantages as regards cleanliness, ease of application, etc., yet if used on general mill and factory machinery they will tend to add to the friction load over what it would be if oil were used.

One of the best illustrations of this in the writer's experience came as the result of a series of tests to see just what this would amount to in the case of the plungers of water-works pumping engines. The first test was made on a vertical compound pumping engine running under a constant load and at 20 rev. per min., having 4 plungers, two being $31\frac{1}{2}$ in. in diameter and two 22 in. in diameter, all having a uniform stroke of 64 in. The plungers were packed with square hemp packing, which had been well soaked in oil before being placed in the stuffing boxes, and several times a day the plungers were swabbed with oil. Two sets of indicator cards were taken. The first with the plungers lubricated with oil showed the engine to be developing 762.67 h.p. The plungers were then smeared with soft grease and time enough given to allow it to become well soaked into the packing, about one hour, and another set of cards taken which showed the engine to be developing 835.17 h.p., making an increase of 72.5 h.p., or over 10 per cent. We could not believe that there could be so much difference, so we repeated the test on another engine of the same size, make and h.p., with the same results. Figuring from a coal consumption of 2 lb. of coal per h.p. per hour, the increase would amount to 145 lb. of coal per hour, or 3 480 lb. per day of 24 hr. As there were eight engines of this same size and make, this would make a total increase in the friction load of 580 h.p., and an increased coal consumption of 27 840 lb., over 13 tons per day, so that in this particular case grease would have been a very expensive lubricant to use.

On the other hand, there are places where grease is the only lubricant that can be used. For instance, in rolling mill work, owing to the nature of the duty and the construction of the machinery, it is the only lubricant that can be used successfully. On rolls used for rolling rails, structural steel and in what we know as merchant mills, the journals or necks are kept flooded with water, a saponifiable grease must be used, that is, one containing a large per cent. of fatty oils, so that it will adhere to the wet surfaces.

In sheet-steel and tin-plate mills where it is impracticable

to use water, and the journal or neck temperatures often go over 400 degrees, a dense grease compounded with a large per cent. of high flash test petroleum oil must be used.

DISCUSSION.

THE CHAIRMAN (MR. F. W. DEAN). — A great deal has been done within a comparatively few years in regard to the economical use of oil on engines for stationary purposes and on locomotives. I remember a number of years ago — I haven't paid much attention to the matter for years — when the oil consumption of locomotives was rated by the number of miles they would run per pint of lubricating oil. At that time the Lake Shore & Michigan Southern Railroad was the most economical in the use of oil, running some 25 miles per pint of lubricating oil, while many other roads were running from 8 to 15, and it was quite a mystery to know how the Lake Shore road, which ran through quite a sandy country, was able to do so well. In 1889 and thereabouts, and about the time the Old Colony Railroad took the Boston & Providence, the record on that road was, if I remember rightly, 9 to 12 miles to the pint. While the Park Square Station was in use the locomotives that took out the express trains used to back on an outside track at the left side of the station to take baggage and express cars, and there the oiling was always done. If anybody had dug up the oily earth that was under a portion of the track and squeezed it out, he could have made a small fortune on oil. Most of the oil went on the ground. After the Galena Oil Company took the matter up — that was after the New Haven Company took the road — there was quite a change. I am under the impression that they made a guarantee of oil consumption, and they began to increase the mileage per pint of oil and went far beyond the former Lake Shore rate. How it is now I do not know. In stationary engine plants the old-fashioned way was to lubricate the engines and make no effort to recover the waste oil. Now it is the regular thing to recover oil, filter it and use it over, so that the new oil required is simply a make-up supply.

MR. FRANCIS H. BOYER. — I am sure we are under an obligation to Mr. Davis for the valuable information he has brought us. But from the standpoint of the operating engineer, I think there is one story I'd like to tell that bears on this question, where we made a saving of about 90 per cent. in our cylinder oil used. We were operating a plant in which there were two cylinders 32 in. in diameter, and 32-in. stroke Corliss engines, work-

ing under 90 lb. of steam. In operating these engines at regular periods there would be severe chattering on the valve seat, also in the steam cylinder, and we had valve stems twisted from this same cause. When the periods of chattering occurred the attendant would open his lubricating cup and permit a stream of oil fully ¼ in. in diameter to flow into the cylinder, often feeding a quart cup full of oil in a few minutes.

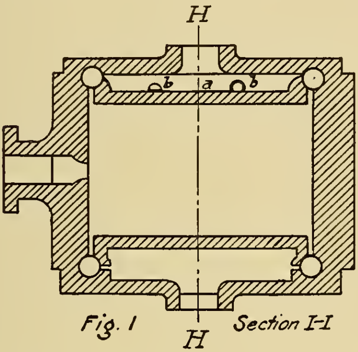

Fig. 1 Section I-I

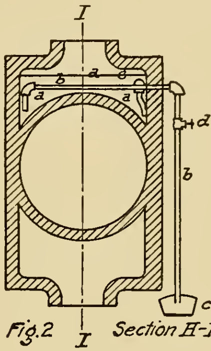

Fig. 2 Section H-H

Upon examination we found that a large chamber was formed by the exterior walls of the cylinder and the walls of the steam chest, as shown in *a*, *a*, *a* in accompanying sketches, this water rising until it flowed over the valve seat, shown at *e*, Fig. 2. This water came from the condensation from the steam in transit between the steam boilers and the engine, a distance of approximately 60 ft.

It was evident that this water must be trapped off. Not wishing to make holes for pipe connections on both sides of the cylinder, we had piping put in as shown at *b*, *b*, *b*, the end of the pipe in the pocket being open. At *d* we placed a valve and terminated our piping in steam trap at *c*. The cavity formed around the cylinder was of size to hold fully 15 gal. of water. Upon completion, we started the trap on the first engine, the trouble ceased, and we had no difficulty afterwards.

One thing more, a remarkable thing in reference to our steam plants. In the last few years there has been a change in the steam pressures that are carried, and this has a direct bearing on the amount of lubrication used. Not long since I came from Norfolk on a steamer with three cylinders and one shaft operating under 175 lb. per sq. in. of steam. Upon inquiry I found the consumption was about one quart of oil the whole distance on her three cylinders. The temperature of the entering steam at 175 lb. pressure per sq. in. is 370.8 degrees. At this tem-

perature we are approaching the burning point of oil, and as a result a sediment of carbon will form in the cylinders which is very detrimental to their operation. So that I think a good deal of economy in the use of locomotive oil to-day may be due to the use of steam at different temperatures from what was formerly used. Not long since I was talking with Mr. J. B. Herreshoff — perhaps it was ten years ago — and he called my attention to the fact that on his torpedo boat, the *Cushing*, which was then building, and operating under 250 lb. steam, he used no oil. "Why," he said, "I dare not use any oil at all in my cylinders for fear of the carbonization which will form on the walls of the cylinder." Now we are changing in engineering, and it may be that this excessive economy we are getting to-day in the use of oil in our engines may be due to the use of 180 to 225 lb. of steam without lubrication.

THE CHAIRMAN. — I want to take the liberty of calling on Professor Hollis to tell us something about the methods in the navy of lubrication, both for cylinders and other bearings.

PROF. IRA N. HOLLIS. — I went through the lard and sperm oil period thirty years ago, and then, before leaving the navy, reached the modern period of using no oil at all in cylinders. Not only is the use of lard oil, or any animal or vegetable oil, in the cylinders for marine purposes bad for the cylinders, but it is also destructive to boilers, as it goes through the condenser, is fed into the boilers and is very bad on steel, both on account of corrosion and of deposits that harden under the action of the fire. I recall a type of boilers which the engineer-in-chief of the navy used to tell me was an 8-in. boiler. It was really 8 ft. in diameter. There were several ships built in which that boiler was used, and I think only ten of the boilers out of about fifty escaped damage in the course of two or three years on account of grease deposits. Inasmuch as I was on the ship that had the fewest accidents, I put the accidents entirely to the use of olive and sperm oil in the cylinders. We found that the steam acted on it and formed it into balls which collected in the condenser, or the hot wells, and then passed into the boilers, where they caked on the heating surface.

But regarding the use of oils on modern vessels, I don't believe it is possible to run a horizontal cylinder for marine purposes without oil. I tried it a number of times. But in the majority of upright engines there is no necessity of using oil. In the battleships — those now going around to San Francisco — they use no oil at all in the propelling cylinders, and they are

now forbidding the use of oil in all engines. In that connection I can, perhaps, bring out one point of greater interest than the use of oil in the navy, and that is the effect of oil on the inside of the cylinder. Mr. Davis was good enough to refer a little while ago to the increase in horse-power due to a change of oil — if I understood that right.

Mr. Davis. — What I referred to was an experiment to see what the difference was between using oil and grease on the plungers of water-works engines. We found we got a greater horse-power by the use of grease than we did when using oil, this increase in horse-power being due to increased friction.

Professor Hollis. — In the steam cylinders?

Mr. Davis. — No, the water plungers. We got a greater indicated horse-power by the use of grease than without.

Professor Hollis. — Now, this brings out another point in relation to the use of oil. I am not violating any confidence, I think, in stating the experience of one of our firms who agreed to build some vertical engines on a limited consumption of steam. The engines were to be run without oil in the cylinders. It was found on trial that without oil the consumption of steam exceeded the ordinary consumption with oil in the cylinders by nearly 20 per cent. Now, the question is, To what was that due? The question put to me was, What was the difference and why should there be so great a difference? Was it due to the fact that oil acted as a non-conductor on the surface of the cylinder and in that way prevented initial condensation? Was it due to a reduction in the leakage losses? Was it due to the fact that, inasmuch as these cylinders are used with condensers, that some of the oil on the stuffing box prevents a leakage of air into the exhaust? Was it due to the fact that there is 20 per cent. friction in the piston and stuffing box of the steam cylinder? I know very little about the effect of oil as a non-conductor of heat, and I have never conducted any experiments for the purpose of determining it. I doubt very much whether the use of oil will prevent leakage of steam from one side of the piston to the other. I am quite sure the use of oil would give a higher mechanical efficiency. Perhaps Mr. Davis would be good enough to tell us if he knows anything about the use of oil in a cylinder and its effect upon initial condensation.

Mr. Davis. — I never heard that point brought up before. It is very interesting. I shouldn't think, though, it would have very much effect.

Professor Hollis. — The people who brought it up found

the question a very important one in connection with their contracts.

A Member. — I'd like to ask what was the pressure of steam for marine purposes?

Professor Hollis. — The steam was all the way from 100 to 150. I have never had the responsibility for a horizontal cylinder where I would trust it without oil for marine purposes. I don't know how that is for stationary purposes. The last engine I was with — the one where I really attempted to try the thing out — we had two cylinders, one 85-in. cylinder and the other a 42-in. cylinder, with a 42-in. stroke, and two piston valves on each cylinder, the engines being 3 500 h.p. each. We used plenty of oil. We had to. One of the things I noticed was that cutting down on the oil considerably gave us a good deal of trouble with the low-pressure cylinder in starting. There was always plenty of water which pounded for hours under such conditions. Now, a person going to sea, and especially going over the bar at San Francisco, with a low-pressure piston cutting up that way at every stroke, knowing there is water in the cylinder and wishing to get it out, is not going to experiment very long. Then, too, the piston valves, the low-pressure piston valves, had snap-rings in them $\frac{5}{8}$ in. square and valves 28 in. in diameter, two for each cylinder. Steel was used in the rings instead of cast iron, and a great deal of oil was required to keep them from cutting. I think they ran dry very often. At the end of six months I took one of the rings off and examined it. It was still $\frac{5}{8}$ in. wide, but its thickness varied in different places between $\frac{5}{8}$ and $\frac{1}{8}$ in. That is, it had gotten down to a thickness of $\frac{1}{8}$ in. in places. Of course, the rings were promptly replaced. The excessive wear may have been due to the difficulty of oiling.

I don't like to prolong this conversation, Mr. President, but there is another point that was taught me when I was a cadet at the Naval Academy; that was, when once you started to use oil in a cylinder, you never could stop it. For twenty years I believed that. I think now it is a mere superstition. I am perfectly satisfied that you can take any cylinder and use oil in it, and if you have a little patience in getting rid of the oil, you can use the cylinder without oil just as well as if you had begun without oil. I am inclined to think if there is a little bit of oil at the start it will give you a good surface and you can run without it afterwards.

The Chairman. — I am glad to hear Professor Hollis speak of the superstition that if you brought an engine up badly

by the use of oil you must keep on. Before we go further I should like to ask him if he knows whether there are any steamships in the mercantile marine — transatlantic ships — running without cylinder oil.

Professor Hollis. — I think so, Mr. Chairman. I have been in the engine rooms of a number of merchant ships that do not use oil in vertical cylinders. But I can't remember the names of the lines. I have seen cylinders run without oil, and I don't see any reason under the sun why a vertical cylinder should not be run without oil. But I still believe that oil ought to be used in a horizontal cylinder on account of the weight of the piston. You get into trouble as soon as you attempt to run a horizontal engine without oil.

Mr. Dean. — Mr. Davis has spoken about the advisability of beveling the piston-rings of cylinders to help along matters. That brought to my mind some things that I heard in Fall River several years ago. At one mill — I have now forgotten the name — where there was a large horizontal compound engine, for a long time it gave so much trouble with the low-pressure cylinder that the head was taken off and the valves at that end disconnected, and the cylinder was run single-acting. Every now and then, with a squirt gun, oil was squirted into the cylinder. Finally an engineer from another mill suggested that if one of the packing rings from the piston were taken out — there were two rings some inches apart — there would be no further trouble. His advice was followed, the cylinder head put on and the trouble stopped. In other words, one packing ring in the cylinder probably scraped all the oil away, so that the lubricating effect was greatly diminished. I should be glad to hear from anybody else on the subject.

Mr. Francis H. Boyer. — I would like to make another reply to some remarks the gentleman has made. Many years ago, before the introduction of mineral oils for lubricating, we used the best lard oil for the lubrication of cylinders, and I know from experience that it was disastrous. Take the best steam cylinder and valve seat and lubricate them with lard, and in about nine months you will find that the whole face of the metal becomes spongy. Holes are eaten in it, bolts will be destroyed. This is due to the action of the sulphur in the decaying process of lard oil, the sulphate of hydrogen you get in all animal substances, which is rapid in its attack on iron. I have seen many cases where the surface of the metal was absolutely destroyed, honeycombed like a loaf of bread, as a result of the use of animal oil.

Mr. Davis. — I can bear out the gentleman's statement in regard to that. I commenced as oiler on lake steamers in 1879. We were then using tallow in the cylinders. My first experience as oiler was on a side-wheel beam engine boat. We kept a can of melted tallow on top of the cylinder. Every once in a while we'd have to fill the cup up, and we always had to be careful to open the cup when the piston was going up, so the vacuum would suck the tallow in. When we'd take the cylinder head off we'd find it all corroded, just as you say, — threads eaten off, the surface of the follower-plate corroded and honeycombed, and inside the piston we'd find full of little balls. The tallow and iron rust combined with dirt caused this accumulation in the form of balls. I had been sailing two or three years before we commenced to use compounded petroleum and animal oils.

Mr. Boyer. — A little story about animal oil may be interesting and will but take a moment, if you will permit me. Lard oil, as a rule, is made from the refuse of hogs mostly, hogs that arrive dead from suffocation or other causes in shipment. Before rendering begins a certain amount of decomposition has already taken place, which means that the flesh and bones are passed back into free gases. When the rendering is completed the greases vary in color from mahogany brown to a light yellow. After a long series of experiments we found that the color of the grease was due to the iron that had come from the receptacle in which it was rendered. If we took the same quality of material and rendered it in any receptacle where it didn't come in contact with iron (for instance, a wooden pail; we first started in aluminum pails), we had just as beautiful white lard as any one would wish to see, and made out of hogs which were rotten. You can imagine what it meant, thousands of dollars to these packing men, where they turn out 4 000 or 5 000 lb. daily, varying from $\frac{3}{4}$ to $1\frac{1}{2}$ cents a pound difference in price. Now you can see how that oil affects machinery. Wherever there is a joint, wherever the sheets are riveted together, it will get in and eat those rivets off; that is due to the sulphur which results from the decomposition of animal substances. That is the reason why it is not advisable to use animal oil for any practical purposes in contact with iron surfaces.

A Member. — In a plant where the lubricant is used over and over again, what percentage of it is lost? There must be some loss.

Mr. Davis. — You mean the loss that takes place by evaporation or something like that?

Member. — Yes.

Mr. Davis. — I think that would be almost negligible unless the bearings become overheated. Under ordinary conditions the loss due to leakage in handling is the only loss worth considering. There is always some loss due to that; some spattering out over the engine frame, leaking through the oil screens and so on. But the amount of loss due to evaporation or anything like that would be negligible. Take an engine oil that would have a flash test of 400 degrees, used on ordinary engine bearings would never be subjected to a temperature high enough to cause evaporation to take place.

Mr. Fuller. — May I ask Mr. Davis whether this filtration of which he speaks is anything more than straining?

Mr. Davis. — That is all, straining, and generally the simpler the better. All that is necessary is to get the dirt out of it.

The Chairman. — Mr. Davis, what is the best filtering material?

Mr. Davis. — I don't know that anybody can tell what is the best. All sorts of things are used. Three different types of filters use cotton flannel. Some filters use cotton waste as a filtering medium. I have seen filters that used excelsior as a filtering medium with very good success. The dirt in the oil would adhere to the wood and shavings and the clean oil would pass through. Sponges have been used as a filtering medium. You can take ordinary engine oil and give it time enough and it will precipitate nearly all its dirt in the tank. But if you want to filter as quickly as possible, the best thing is to put it through some filtering medium.

Mr. Irving E. Moultrop. — I wish to say a few words in reference to Mr. Boyer's remarks regarding the possibility of eliminating cylinder oil on account of the higher steam pressures which are being used at the present time. I believe that the higher steam pressures in present use do not necessarily tend to dispensing with cylinder lubrication, although in some cases the higher pressures may make it possible to reduce the quantities of oil used.

In our turbine station at South Boston we are running 175 lb. boiler pressure, superheated at the boiler to about 150 degrees fahr.; allowing for a reasonable drop in temperature between the boiler and the steam cylinders, we get a total temperature at the cylinders of about 500 degrees.

Our auxiliaries are mostly horizontal machines, and we

find it desirable to use a certain amount of cylinder oil on all of them. Of course when these machines are started up after having been shut down for a certain length of time, and the steam parts have become fairly cool, there is considerable condensation in the cylinders, but after they have been running for a short time and thoroughly warmed, there is doubtless very little condensation, yet we have never felt that it would be good policy to dispense with cylinder oil, even though the condensation was entirely eliminated.

Mr. Theo. O. Barnard. — I should like to ask, in connection with Mr. Moultrop's question, if Mr. Davis can give us any information on desirable oils for use with heavy duty engines using superheated steam. We find there are a great many heavy-duty engines, horizontal engines in cotton mills that have ammonia compressors that are now using superheated steam, and operating engineers have had in many cases a great deal of difficulty in properly lubricating the walls of the cylinders with the various oils that have been suggested for the purpose.

Mr. Davis. — I should say that for use with superheated steam an oil ought to be of high flash test, that is, 550 to 575. There is such a thing as getting the flash test too high. Of course, any manufacturer of oils, in order to get a higher flash test, has to reduce the oils down to drive off the more volatile products. Consequently, as the flash test increases, the density increases also. It becomes more viscous, and while viscosity is a good thing for an oil to have, there is such a thing as having too much viscosity, so that it doesn't atomize and spread out well. It becomes tarry. So you have to strike a happy medium. I should say 550 to 560 or 570 degrees would be sufficient flash test. If you have perfectly dry steam it may be possible to use only a straight petroleum oil. But take a compound engine, when you come to lubricate the low-pressure cylinder you will find a good deal of condensation. There is a big drop in temperature and a corresponding increase in condensation. In order to secure lubrication under those conditions you have to have an oil compounded with animal fat to make the oil stick on to your surface. That is all the animal fat is used for. Petroleum oil has no affinity for water, and if used alone would wash right off. The best animal matter to use is what is known as acidless tallow oil, although some companies use neat's-foot oil.

DISCUSSION — Continued at Meeting held February 12, 1908.

Mr. James F. Monaghan (*by letter*). — That part of the discussion referring to the running of steam cylinders without lubrication brings to mind a pair of horizontal engines which might be of interest to refer to. It is customary in nearly all bleacheries and dye works to use low-pressure steam for boiling and drying the cotton cloth. This steam is reduced from high to low pressure in some plants, and in others is taken from the exhaust steam from the engines working against a back pressure of 5 to 10 lb. per sq. in. When this exhaust steam is drawn into a kier in which the cotton cloth is to be boiled in alkaline liquor for the bleach, it of course carries along with it a part of the oil from the cylinders. This oil is objectionable, for the purpose of the alkaline boil is to remove all oils, fats, etc., in the cloth.

In the case of the two engines to which I refer, the installation was started with oil used in the cylinders, but this idea was later changed and these engines ran for about ten years without any cylinder lubrication, in order to obtain an exhaust free from oil. At the end of this time the use of oil in the cylinders was resumed, and the engines are to-day running lubricated. Before the internal lubrication was resumed, however, it was necessary to rebore the cylinders and fit new rings to the pistons. These engines were of the Corliss type, each 36 in. diameter of cylinder by 60 in. stroke, running 60 rev. per min., with a steam pressure of 90 lb. per sq. in. They were coupled together on the same shaft, at times running together, and often with one side or the other disconnected.

In another bleachery, I know of a pair of Corliss engines of about 350 h. p. each, exhausting against a back pressure of 8 lb. per sq. in. with both cylinders lubricated, and the exhaust steam is used for boiling in the bleaching kiers. Here no attention is given to the oil carried in with the exhaust. The amount of cylinder oil used per cylinder is one pint for every 3.5 hr. run, and these engines are 26 in. diameter of cylinder by 48 in. stroke. One engine runs 76 rev. and the other 62 rev. per min., with the oil consumption the same in each case. The steam pressure is 90 lb. per sq. in.

Mr. W. M. Davis. — I will say that while I have known of cases where horizontal slide valve engines were run without cylinder oil, this is the first instance I have ever known of a Corliss engine running without cylinder oil.

The Chairman. — It is the first case I ever heard of.

Mr. Davis. — I remember in Pittsburg, where I lived for a

number of years, that there was a plow works in which they had an old horizontal slide valve engine that made, as I recollect it, about 50 or 60 rev. per min. I think it was about 24 in. in diameter, with perhaps a 36-in. stroke. I don't think the steam pressure was more than 60 or 80. It was a very old-fashioned plant. That engine never had a drop of cylinder oil in it. The old engineer who had been on the job ever since the plant started, I think, said there was no place to put cylinder oil in, and he never used a drop. He said he wouldn't use cylinder oil in any cylinder. But he never worked anywhere else. I don't know what he would do if he went as engineer in some of the rolling mills I know of around Pittsburg.

I do not doubt but what horizontal engines can be run perhaps successfully without cylinder oil if soft metal rings are put in or tail rods used to support the piston from the bottom of the cylinder, and grooves cut at the ends of the valves so that there will certainly be a good flow of moisture in between the valve and the valve seats, especially a Corliss engine. It is just possible that large engines could be run without the use of cylinder oil. But the chances are there would be more friction than there would be with oil. Perhaps the loss from increased friction would offset the saving.

The Chairman. — Where you speak of this lubrication, you mean the bearings?

Mr. Davis. — No, the ends of the valves where they rest in the castings. They should be so grooved that the steam will flow in. It will probably be in such shape that there will not be any great amount of wear; that is, it will not stick. But in that case Mr. Monaghan speaks of, the engine was run for ten years without the use of oil, if I understand him right.

The Chairman. — Yes.

Mr. Davis. — He said the engine was run ten years without the use of oil, and when they began to use it they found it necessary to rebore the cylinders. Well, I have known many cylinders on which oil was used in such large quantities that it was necessary to rebore. Sometimes it is necessary more than once in the course of a year.

Mr. W. G. Starkweather. — That question of grooving mentioned by Mr. Davis is important. I remember an instance near this city where we had a heavily-loaded vertical cross-compound engine on which the high-pressure crank pin caused considerable trouble, despite all the oil that could be put on it. After some experimenting, and just as the owners had

about decided to put in a new pin, the right combination of grooving was found, and that pin is running satisfactorily to-day without other change. The new grooves distribute the oil to the right place. That was the whole secret of it.

Mr. Davis. — I can readily appreciate that. I know cases where they had the same trouble that you speak of.

Mr. Starkweather. — It might be interesting to state what is being done on the large gas engine cylinders to-day in the way of internal lubrication. In our gas engines we are obliged to use a grade of oil that will stand the high heat of the combustion. It is pumped in on top, at each end of the stroke, just as the piston reaches the hole, so that it is carried back and forth on the piston between the rings and flows around it and is distributed as it flows, thus lubricating the cylinder walls. The pistons are all supported by tail rods.

As well known, the lubrication of bearings, pins, slides, etc., has been threshed out pretty carefully, and the oiling apparatus of an engine is well developed. The engine to-day also has guards over the eccentric crank and at the slides, so that the oil is put on freely and kept from getting away, and can be collected, filtered and re-used.

The Chairman. — I notice in your paper, Mr. Davis, that you speak of the small amount of oil that is lost in modern methods of lubrication and prevention of waste. But of course there is always being added a certain quantity of new oil. Do you know what relation there is usually between the make-up supply and that which is actually run on the bearings?

Mr. Davis. — I have no data that will give you anything authoritative on that. No two cases are alike. Just as Mr. Starkweather says, they are providing shields and pans and everything to retain the oil. That is the secret of economical lubrication, — to take every means possible to prevent the oil from being lost. It does not matter how much you put on the bearings, if you can recover 99 per cent. of it, your loss is only 1 per cent., no matter if you use a barrel an hour. On the other hand, if you only use a gallon an hour and lose all of it, your loss is 100 per cent. So in modern engineering it is customary to go to considerable expense to prevent these oil losses. But there is always some loss from wiping up, but just how much I could not say. Even where the engines are very well protected with shields, pans, screens, etc., in wiping up around the machinery there is a little loss.

I was at quite a large paper mill some time ago, where they

make a point of gathering up all the oily rags. They use rags there instead of waste, and put them through one of these oil- and waste-saving machines. While those rags do not seem to be very oily, that is, thickly saturated with oil, yet they recover over a barrel of oil every week by so doing. Besides, they get the use of the rags again for wiping. They have a man that does some other work and every so often he gathers up all these oily rags and puts them through this machine. And then the oil is filtered and used around the plant again.

Mr. Starkweather. — Is that machine you speak of a press?

Mr. Davis. — No, it is a centrifugal machine. There is a steam pipe in connection with it, and the hot steam and centrifugal action extract the oil from the rags and waste.

The Chairman. — There has recently been brought out, at least it is new to me, an oil filter which works by centrifugal action. It is a very small affair compared with the ordinary filters.

Mr. Davis. — I think it is the same company that makes that oil- and waste-saving machine. I will say that some years ago I made some experiments in cleaning oil by the centrifugal process. I used an ordinary creamery separator and got excellent results. I took some of the dirtiest oil I could find in the bottom of the waste oil tank — it was almost black in color — and put it through this creamery separator and got it out as clean and bright as when it came from the barrel. But the separator very quickly clogged up and it was hard to get it clean again.

The Chairman. — Was it as clean as Mr. Boyer's lard made out of rotten pigs?

Mr. Davis. — It seemed to be so. They got pretty clean lard, when they treated it right, from rotten hogs. It is too bad that Mr. Boyer is not here to-night to tell us more about it. A company has recently brought out a centrifugal oil filter, a clarifier they call it, but I have not seen it yet nor do I know how good it is.

A Member. — Can Mr. Davis give us any idea how often oil should be used over again?

Mr. Davis. — Oh, yes, as long as you can catch it. Take some of these small-speed engines. They have a small tank and pump arrangement connected right on the engine, and the oil keeps circulating over and over again. It goes over the bearings, thence into this little tank, which has a strainer in it, and from there is pumped back over the bearings again.

THE CHAIRMAN. — Is there nothing in the use of oil that injures it at all?

MR. DAVIS. — In the case of the high-speed engines there is but little chance for dirt to get into it. Everything is protected. I have seen oil that had been in use several weeks without any being added to it, and it looked as clean as when it was put in.

A MEMBER. — Does oil actually wear out, or simply waste?

MR. DAVIS. — Simply wastes.

A MEMBER. — Is there no such thing as wearing out?

MR. DAVIS. — Some years ago, before it was the practice to filter oil as it is now, many engineers claimed that oil was not fit to use after it had been used once; "that the life was worn out of it," and so on. I know when I first went to the American Sheet and Tin Plate Company as oil inspector and commenced to introduce economies such as the saving of oil by filters, etc., that was a common idea among some of the engineers, "that oil once used might be good enough to use on mill machinery, but not to use on an engine."

A MEMBER. — Well, some of the oil used on turbines is quite light in color. But after being used, even when it is filtered, it has changed its color and consistency quite a little.

MR. DAVIS. — Yes, it will usually get a little darker.

A MEMBER. — Is that simply iron?

MR. DAVIS. — It may be due to metallic wear, but it is not enough to affect the quality of the oil; it only affects the color.

A MEMBER. — It is wholly the color? Nothing detrimental to the oil?

MR. DAVIS. — Nothing.

A MEMBER.— This is why I asked the question: I had a turbine engine and the Standard Oil man who furnished the oil said it should not be used more than fifteen times in 24 hr. This plant has a duplicate filter. He wants one filter to be used one day and the other to be used the next day, the oil to rest meantime. But we are using it about thirty times in 24 hr. It is a Curtis steam turbine plant and we get emulsion in the oil.

MR. DAVIS. — If there was water in the oil that would give it time to settle out; perhaps that was the reason.

A MEMBER. — He is trying to get rid of emulsion, which is very considerable. But in the design of the General Electric plant at Schenectady, he advised not to use oil more than fifteen times.

MR. EDWARD B. RICHARDSON (*by letter*). — In the recent contribution on "Economical Lubrication of Large Plants" by

Mr. Davis, and the consequent discussion, but slight mention was made of lubrication in turbine plants. Thinking that the experience in such a plant of 2 500 kw. capacity of Curtis turbines might be of interest, the following outline is presented:

In the plant in mind two 1 000 kw. and one 500 kw. turbines are installed, having, as is usual, oil lubrication for the steady and step bearings for all units and in addition for the larger two oil governor control.

Two 15 gal. per min. oil filters are installed, having each a storage tank of 400 gal. capacity. The oil returning from the turbines by gravity enters the filters at one end, rises through water, which can be heated to about 200 degrees fahr. by a steam coil and through trays of excelsior. It then passes through two more similar compartments, except that no steam coils are provided.

After the cleansing done thus it flows into the storage compartment, where it is cooled by contact with a pipe coil of cold water. From the storage compartment it flows on to the oil pressure piston pumps, which distribute it at about 500 lb. per sq. in. pressure to the supply piping system.

Considerable trouble has been experienced by the formation of a thick, milky emulsion, which occurs in more or less quantity. This emulsion has occurred with two different oils, and the opinion is advanced by the company furnishing the last lot of oil used that the trouble is due to too frequent use of oil, thus not allowing opportunity for clarifying.

The oil is guaranteed a pure petroleum distillate, with no compounding and with blending only sufficient to maintain its uniformity. Analysis of the water used in the plant shows no chemical property which would produce a chemical action.

The explanation of the formation of the emulsion is as follows: Oil having a natural tendency for holding a certain amount of water, the churning effect when it passes through the pumps causes a more or less perfect mechanical mixture, thus producing the emulsion. A certain small per cent. changes composition by chemical action. It is claimed that if the oil is allowed time for settlement, the emulsion, except for this small per cent. (about one), will separate into its component parts of oil and water.

The manufacturer claims that no oil should be given harder service than by using it more than fifteen times in 24 hr., whereas the oil in this plant is re-used about thirty-three times with all units operating, the quantity per minute being 12 gal. He claims

that if on any system one filter is used for 24 hr., and then the other is used for a similar length of time and with proper heating, the emulsion will disappear, except for this small per cent. of changed formation.

Since oil engineering for this kind of plant with the use of oil at high pressures and in bearings where the circumferential speed of the shafts in the bearing may be as high as 2 500 ft. per min. is a new problem, the machine as well as the oil manufacturers have to take a hand in solving the problems arising.

It is the opinion of the oil manufacturers supplying the oil in this case that more care must be given and a more extensive system designed than has been required in continuous oiling systems for engine plants.

Since the system in mind has not been changed as suggested, certain features having just been reported upon, it is impossible at this time to give information in regard to the solution of the problem, but the above is contributed with the thought that it may furnish some member with information for thought, or may afford him help should he be working on a similar problem.

[Note. — Discussion of this paper is invited, to be received by Fred Brooks, Secretary, 31 Milk Street, Boston, by July 1, 1908, for publication in a subsequent number of the Journal.]

SOME HISTORICAL FACTS AS TO THE DISCOVERY AND USE OF THE MAGNETIC NEEDLE, AND SOME FACTS FROM THE AUTHOR'S EXPERIENCE WITH THE COMPASS AND JACOB STAFF IN LAND SURVEYING IN LOUISIANA.

By M. P. Robertson, Member of the Louisiana Engineering Society.

[Read before the Society, December 9, 1907.]

Gentlemen: I have chosen for my theme a subject with which I have been made familiar from long experience in practical field work, rather than travel the beaten paths of levees and high water on the Mississippi River and its tributaries, the latter subject having been diligently threshed and winnowed by my colleagues engaged on river work, so that bags both of tares and wheat were scattered broadcast throughout the engineering world.

Historical. — The earliest references to the use of the compass were Chinese. Just as we got the art of roasting pigs from Hoti's promising son Bobo, and gunpowder from the Chin-Fous and Goiden Chops, the great historian Ah-sam has it that in the sixty-fourth year of the reign of Ho-Ang-Ti, 2634 B.C., the Emperor Hiuan-Yuan or Ho-Ang-Ti attacked one Tchi-Yeou on the plains of Tchoulon, and, finding his army embarrassed by a thick fog (raised by the enemy hitting the pipe) constructed a chariot for indicating the south, so as to distinguish the four cardinal points, and was thus able to pursue Tchi-Yeou and take him prisoner. Be it as it may, the Chinese, to whom we owe the rudiments of so many sciences, have always stopped at the beginning and worked backwards, for if we continue our research we find that under the Tsin dynasty of between 265 A.D. and 419 A.D. there were ships directed to the south by the needle. The Chinese once navigated as far as India. The name Ting nang ching, or needle pointing to the south, shows them again as turning their backs upon Polaris, the guide of modern navigators and surveyors; and they still reckon all points from the South Pole, as in this country they are reckoned from the North, which shows beyond doubt that we have improved on them. It is claimed that the needle was given by them to the Arabians, and by the Arabians to the Europeans.

However, the first person to bring it into notice in Europe was Marco Polo, a Venetian, born 1254 A.D., died 1324 A. D. At the age of seventeen, in company with his father Nicolo and

uncle Maffeo, he traveled through Tartary and across the great desert to Gobu and Tavgut, thence to Shoughu, where they found Kublai Khan in 1275. They were kindly received by the great Khan and retained in the public service. Marco Polo rose rapidly in the emperor's favor and was employed in various missions in different parts of the empire. Marco with his father and uncle left China in 1292 and after many adventures reached Venice by way of Sumatra, India and Persia in 1295. In 1298 he was taken prisoner in the battle of Curzola between the Venetians and the Genoese. Here he dictated an account of his adventures to a Frenchman, in a work called "Rusticiano of Pisa," which obtained wide popularity.

Flavio Gioja, of Amalfi, Naples, about 1362, is also claimed as the inventor or introducer. So also do the English claim a knowledge dating back many years before Columbus, and contemporary writers ridicule the idea of either Marco Polo or Flavio Gioja's claims. It is not unreasonable to suppose that all Christendom brought back some knowledge of Eastern science from the various crusades to the East, covering the period from 1081 to 1250. By all Christendom there is also no doubt that to Marco Polo is largely due the discovery of America, since his work on his travels to the great Khan is cited by Fernando Columbus, the son of the great Admiral Christopher Columbus, in corroboration of the idea that Asia, or, as he always termed it, India, stretched far to the east, so as to occupy the greater part of the unexplored space. The narratives are cited of Marco Polo and John Mandevelo, travelers who had visited the remote parts of Asia, far beyond the regions laid down by Ptolemy, and their account of the extent of that continent to the eastward had a great effect in convincing Columbus that a voyage to the west of no long duration would bring him to its shores or to the extensive and wealthy islands which lie adjacent.

Be it as it may, the results obtained by those who preceded Columbus are but small compared with those achieved by him. Washington Irving, in his "Life and Voyages of Columbus," Book III, chapter 11, in my opinion sets at rest the question as to the discovery of the variation of the needle. He says:

"On the thirteenth of September, in the evening, being about two hundred leagues from the Island of Ferro, Columbus, for the first time, noticed the variation of the needle; a phenomenon which had never before been remarked. He perceived, about nightfall, that the needle, instead of pointing to the north star, varied about half a point, or between 5 and 6 degrees, to the northwest, and still more on the following morning. Struck with

this circumstance, he observed it attentively for three days, and found that the variation increased as he advanced. He at first made no mention of this phenomenon, knowing how ready his people were to take alarm, but it soon attracted the attention of the pilots, and filled them with consternation. It seemed as if the very laws of nature were changing as they advanced, and that they were entering another world, subject to unknown influences. They apprehended that the compass was about to lose its mysterious virtues, and, without this guide, what was to become of them in a vast and trackless ocean?

"Columbus taxed his science and ingenuity for reasons with which to allay their terror. He observed that the direction of the needle was not to the polar star, but to some fixed and invisible point. The variation, therefore, was not caused by any fallacy in the compass, but by the movement of the north star itself, which, like the other heavenly bodies, had its changes and revolutions, and every day described a circle round the pole. The high opinion which the pilots entertained of Columbus as a profound astronomer gave weight to this theory, and their alarm subsided. As yet the solar system of Copernicus was unknown: the explanation of Columbus, therefore, was highly plausible and ingenious, and it shows the vivacity of his mind, ever ready to meet the emergency of the moment. The theory may at first have been advanced merely to satisfy the minds of others, but Columbus appears subsequently to have remained satisfied with it himself. The phenomenon has now become familiar to us but we still continue ignorant of its cause. It is one of those mysteries of nature, open to daily observation and experiment, and apparently simple from their familiarity, but which on investigation make the human mind conscious of its limits; baffling the experience of the practical, and humbling the pride of science."

I have quoted this part of Washington Irving's history in contravention of the Encyclopedia Britannica, which attempts to demonstrate that one Peter Adsigio, a Venetian, knew its use in 1269, and that it was known in Scotland in 1306. There is but little more reason for attributing the knowledge of the use of the Magnetic Needle to them than the practical use of steam to the Egyptian priests who knew how to blow a steam whistle or keep balls suspended in the air by means of a steam jet, or to Martin Luther when he advocated in a sermon in Germany that steam could be utilized instead of dogs to turn a spit for roasting meat. There are no data extant as to the first application of the compass in land surveying, but the division of the circle into 360 degrees dates back to great antiquity, probably prior to the Christian era. The knowledge of the ancients as to geometry was very great, and the solution of the area of a circle was known to Archimedes, 212 B.C. The magnet was also known to the

Greeks and Romans — its derivation is from the Greek word, "magnes," from having been found near the town of Magnesia in Lydia, — but they knew nothing of its directive force; but what they lacked in definite experimental knowledge they supplied by an abundant use of the imagination. We are told, for instance, that the magnet attracts wood and flesh; it is effective in the cure of disease; that it affects the brain, causing melancholy; that it acts as a love philter; that it may be used in testing the chastity of a woman; that it loses its power when rubbed with garlic and recovers it when treated with goat's blood, and that it will not attract iron in the presence of a diamond.

The science of magnetism made no real progress until the invention of the compass. The acquaintance of the ancients with astronomy was very advanced, and we owe to them the names of the stars in the constellations, also the observation of the planets in the heavens. Their method of determining the north, that is, the meridian, was by means of erecting perpendicularly a pole or rod; with the center of the pole as a pivot and its shadow at early morning as a radius, they described the arc of a circle; then observed at evening, when the shadow again cut the arc thus described, and joining these points by a cord they bisected the cord and from the center of the pole passed a line through the point of bisection, the line thus drawn being the north and south.

To attempt no more than a cursory glance at the subject of magnetism is all I intended, as to it are due so many scientific inventions of the age, and any attempt to go deeply into this subject would require volumes rather than pages. I cannot but feel proud that to America more than any other country is due the discovery of electro-magnetism and magneto-electricity, that have revolutionized modern science and given us a place to-day in the history of the world as first in science; and to no two men is due this great achievement more than to the late Prof. Joseph Henry of the Smithsonian Institution, who discovered that magnetism and electricity were interchangeable, and to Thomas Edison in applying this principle in the invention of the electric light and electric motor. The world, too, has to thank the magnetic needle for our cablegrams and Marconi telegraph, for the safety of our ships at sea, for our land surveys and many other scientific operations. Notwithstanding that the sea has been accurately mapped, the chronometer rated and azimuth points placed at every important port, and the "Sextant and Nautical Almanac" provided for mariners, still, when a storm or a fog is on, our great ships have to resort to the log and the

compass, that is, to navigate by dead reckoning or practically by compass and chain.

It is a common thing for those engineers who have not had any practical experience in the location of land lines to place but a cheap estimate on those who follow that branch of professional work. There is, perhaps, some modicum of justice in this, yet on the whole they are grievously wrong. Some few illiterate people are engaged in running lines occasionally, yet when we sum up the requisites of a thoroughly competent land surveyor we may well respect him. They are as follows: (1) An iron constitution. (2) A knowledge of mathematics beyond what is ordinarily required of a transitman or leveler. (3) The knowledge of a lawyer and the acumen of a detective. (4) He must know human nature and be able to control his temper. (5) He must be able to impart sufficient knowledge in a few minutes to a new set of men on each survey to have them measure and mark properly. (6) He must be able to know which trees will hold an old line and which will not, and know by a glance how old the marks are; in other words, he must be up in practical forestry and more or less a timber expert. (7) He must conform his work to that of his predecessor and perpetuate the errors of antiquity, especially if the survey he is following happens to have been made by a United States Deputy Surveyor. (8) He must be quick to decide whether it is better to cut a log across or wade a bayou or swim it, and in the latter event he must go first in order that his men may follow him. The different requisites mentioned are well known to all of us who have made land surveying our business, and we have probably all passed through the stage of attempting to set ourselves up against the old surveys on the hypothesis that 80 chains make a mile and that 6 degrees and 15 min. equal 6 degrees and 15 min., and not 7 degrees and 45 min., and have had to do our work over again for our pains.

The peculiar difficulties surrounding the greater part of Louisiana lands are due to the fact that under the old French and Spanish grants the land lines were run normal to the water courses and extended into the swamps about 1.5 miles; or, expressed as they mostly were, "so many arpents front by the depth belonging thereunto," meaning 40 arpents, or 116 chains and 36 links. These tracts have lines fitting every point of the compass, being wider on the back than in front in the bends, and closing to a common corner at the 40 arpents' line in points. There are as many as 140 tracts of land in some of our river parishes having a common corner at the back.

The descriptions of land surveys as given refer to tracts that were confirmed to the original owners in 1815, with an additional concession of 40 arpents given in continuation of the bearing of the front concession. The balance of the land was then divided into regular sections of 640 acres, numbered from 1 to 36, and from left to right, and the old grants shown by enumeration above 36, there often being more than 100 sections in one township of 6 miles square. There is also an old United States law ordering all lands on our navigable streams to be divided into lots of 160 acres by 40 acres deep, each measuring 4 acres front by 40 acres deep, side lines normal to the river bank. There are 3 770 miles of navigable streams in Louisiana, so the extent of these surveys may be readily imagined, the back and meander corner being established and the line of every fourth lot run.

The first surveyors in Louisiana were officers in the Spanish and French navy, such men as L'Hermit, Le Sage, De la Tour and others, and their work was very creditable indeed, except that, having no system of connected survey, each tract was on an entirely independent basis, and their work would answer as well for a tract of land in South Africa or China as in Louisiana. The variation of the needle used by them is seldom stated, and the clerk or recorder of conveyances has faithfully maintained this absolute disregard for location ever since. For instance, we boast of records dating back to the old Spanish owners: say McGill Torras owned four or five tracts of land in one parish, all of which he sells at various times. The deed describes thus: "Deed of McGill Torras to Carter Hood: a certain tract of land situated . . . lying and being in the Parish of . . . at about 10 miles from the Courthouse and containing 600 acres more or less," township, section and range not given. So would probably be described each tract, and after the labor of more than a week you will find that his land must be identified by the marks on the ground, after his attorney had advised him that he had an unimpeachable title. What can you do under such conditions but look wise and say little until you have finally worked out the problem in spite of his title?

Speaking of the variation of the needle, have you ever visited the surveyor-general's office and admired the system with which this has been observed? If you have not, then go there and study. In the right-hand corner of his map you will find some such legend as this: Peter Walker located the north boundary in the fourth quarter of 1829 at a variation of 7 degrees 30 sec. east. The interior sections 1 to 12 and western boundary were

surveyed by Daniel Clark in the second quarter of 1830, with a variation of 8 degrees 45 min. east; the eastern boundary and the remaining sections by A. G. Phelps in the fourth quarter of 1831, with a variation of 9 degrees east. Take your compass and close the survey if you can, or plat your work. You will find incongruities that cannot be reconciled. When this work was done on the part of our government just a few years after the cession of this country, the pioneers wrought more with sword and axe than with the sciences, but they were rigidly honest and dared hardships unknown to us. Many times I have traced their lines through trackless forests and wondered how they could have braved the dangers of Indians, mosquitoes and varmints and faithfully executed their duty, especially through the alluvial lands subject to annual inundation. They were generally accompanied by a small party, and it was nothing uncommon for them to divide their provisions and outfit, — coffee, sugar, meat, bread and potatoes and a few cooking utensils,— the surveyor himself carrying strung across his shoulders a side of bacon, their resting place for the night being the shelter of a tree. This was told me by an old citizen who had been in his early youth one of the chainmen of A. S. &. A. G. Phelps (1830).

The general honesty must not be construed to mean that all of our lands were honestly surveyed, as we had in the western part of the state a large number of townships which were surveyed in the office of the surveyor where water courses and lakes, also beautiful ridges, were shown that existed only in the mind of the artist; and worst of all the surveys were accepted.

Speaking of the hardships of surveyors I can well remember in 1879, after admiring the long steps which I thought actually measured a yard, taken by the surveyor with whom I first worked, I concluded to embark upon the arduous duties of chaining. It was during the month of August and extremely hot, and mosquitoes, snakes, hornets and bumblebees were abroad in great numbers; it was the time of the year when the wasp nests were getting ripe. After looking for a considerable length of time for an old corner in the lower part of Bayou Maringouin, a desolate and uninhabited country, we at length found an old post, a charred piece of cypress about 4 in. square, facing the old bearing tree. We had gone probably about 1½ miles, or to the 40 arpent line from that bayou, when dinner time came and the party was nearly famished for water, not having carried any with it in the morning. We had sent back one of our negro laborers for water, and the whole party waited patiently

for his return. After a short time we could see the glitter of the tin bucket in the sun, about a mile distant, and then we became more thirsty and more expectant in anticipation of the drink of bayou water we were about to receive. But sad to relate, our hopes were never to be realized, for in cutting the line over a large fallen cypress we had disturbed a wasp nest, and Jack, who had climbed up to the top of the log, was attacked and came down head first and bucket down, and the total remaining contents of the bucket was about one fourth of a pint. By some accident I failed to be the first to reach the bucket, and my companion, the head chainman, reached the bucket and drained its contents to the last drop. The surveyor, who was himself very thirsty, used some very strong language on this occasion, and my friend, the head chainman, never had any use for him afterwards.

My first experience with the compass and chain in charge of actual work occurred about 1883. It happened that an old gentleman who resided in our town had entered a large tract of land on the Natalbany River, in the Free State of Livingston, and, as an act of great kindness and patronage to me, embarked me out on my first survey, with the necessary funds to pay for labor, chainmen, etc., charged with the duty of finding out whether this valuable land had been depredated upon by being tapped for turpentine. I hired a horse, slung my compass over my shoulder and rode 50 miles to the land. Some of the oldest inhabitants pointed out the corners to me and we started on a survey of 4 000 acres in the pine woods. It took me about five days to complete the job, and at night I studied Gillespie in order to be sure that I had made no errors. I could not disabuse my mind of the idea that in order to find a variation of east the variation on the vernier should be turned to the right, as it was by me; and after I had completed the survey one of my corners was about half a mile from where it should have been, and then I began to get busy and found my error, which was some 14 degrees, and I was compelled to employ the necessary labor at my own expense to correct the error and establish the lines in their true position. I hope this may never happen to any of you.

Personal quarrels between neighbors about matters of an entirely different nature have often caused a most bitter land dispute. I remember on one occasion I was sent to give notice to an old gentleman in Iberville Parish that we would be at the upper back corner of his land the next morning at eight o'clock and there proceed to establish the line. This line had been run

many times because the neighbors did not agree and were not then on speaking terms. The old gentleman read the notice and answered verbally that he would be there and bring his shotgun with him, and so he did, and throughout the survey he followed with his shotgun on his shoulder, but fortunately no one was hurt.

A great many engineers who have been during their entire lives used to the tripod cannot well conceive how a Jacob staff is a useful instrument in land surveying. They say that it cannot be kept at a perpendicular; that it leans from one side to the other, and is unsteady; but did it ever strike you what a weapon a Jacob staff is in the hands of a man who from long experience can hit a spot in the ground every time? Think what a protection it is to him from snakes and dogs! It is an instrument both of science and defense; and, strange as it may seem, through miles of lines the slight errors will correct themselves and you will get a reasonably straight line with a sight compass and Jacob staff.

There are many variations to the needle during the day. The wind blowing across the glass can so electrify it as to prevent it from revolving, but a little water applied to the glass by wetting the finger will overcome this. During the summer months especially the diurnal variation is very perceptible and no line can be perfectly straight without constantly using back sights. But I suppose it is agreed among all engineers that the running of a straight line, even with the most modern and powerful instruments, is one of the hardest propositions in engineering. It is a mere chance when a long tangent in railroad location is perfectly straight, and a subject of great pride to the engineer who has performed this feat, even though he used tacks and checked his sights from hub to hub.

I referred in speaking historically to the imagination of the ancients in regard to the powers of the magnet, but among the ignorant even to-day strange powers are attributed to the magnetic needle. I have been told by some of my help on different surveys that the needle would flutter and flutter and would not pass a pot of gold, but I have never yet been fortunate enough to find one.

Among the greatest men in the history of our nation, at least two of our Presidents have followed the humble calling of land surveyor — George Washington and Abraham Lincoln — and Jay Gould, before he became a master of finance, eked out an existence by setting 12 o'clock marks for his rural neighbors; so that however much we may be inclined to belittle the work of the compass, it has been followed by some of the nation's

greatest men. It was a potent weapon in early days to rob the poor red man of his ancestral rights; and among many of the Indian tribes the surveyor was designated as a land stealer and looked upon with awe and respect.

This paper is not, strictly speaking, a technical paper, and I hope it will be received in the same spirit in which it was written — for the entertainment of the Louisiana Engineering Society.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 1, 1908, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF MR. OCKERSON'S PAPER ON "DEEP WATERWAY FROM LAKES TO GULF."

(VOL. XL, PAGE 110, FEBRUARY, 1908.)

MR. ROBERT MOORE. — The author's statement of the "possibilities of river traffic" as compared with traffic by rail is somewhat misleading.

As a type of river traffic he takes a towboat with a fleet of barges containing 67 000 tons of coal, and as a type of traffic by rail he takes as the load per car 16.9 tons and the load per train 224.4 tons, or less than 14 carloads, these being the average car and train load of the Frisco Railroad for the past year. From these data he finds that to haul the same amount of coal as was contained on the barges would require 298 trains.

For a fair comparison, however, the conditions for the boat and for the railroad should be equally favorable. A boat with the current in its favor should be compared with a train on a water grade line; and certainly the railroad should be allowed to carry its coal in coal cars, which are now built to carry from 40 to 50 tons, and, as every one knows, are almost always overloaded. But on a water grade a locomotive can easily haul trains of from 50 to 60 cars. The St. Louis, Troy & Eastern Railroad, a coal road, brings into East St. Louis trains of this size every working day. For this purpose, however, we may assume a train of 50 cars, each loaded with 45 tons. This gives a train load of 2 250 tons, or ten times the load assumed by the author; and the fleet of barges will represent only 29.8 trains instead of 298 trains as stated in the paper.

Coming next to the speed of the boat as compared with that of the car, the author finds the speed of the towboat and barges to be from 75 to 100, or say 88 miles per day, and the "speed of freight movement by rail" to be but one fourth of this amount, or 22 miles per day, basing the latter figure upon a "high authority" not named.

Now it is true that if from the reports of the Interstate Commerce Commission we take the total freight-car mileage of all the roads in the United States for one year and divide it by the total number of freight cars of all classes and then by 365 days, we shall get a quotient of between 23 and 24 miles per day. The average of the four years, 1903, 1904, 1905 and 1906 is 23.89

miles per day, or, say, 1 mile per hour. But this figure is the average movement of all cars, empty and loaded, for all the days of the year, during a large part of which time they are standing idle in shops or on sidings. Therefore, if this figure be used at all, it should be compared only with the average movement for the same time of all boats of all classes, whether they be empty or loaded, in motion or tied up at landings. But if, in our comparison, we take a moving boat, then surely we should take a moving car. And the speed, even of the slowest freight train, can hardly be taken at less than 10 miles per hour, or ten times the speed used by the author.

The facts of this example afford, however, a good illustration of the limitations as well as the possibilities of the two methods of transportation. The coal on the barges referred to was probably and normally brought from the mine to the river in cars,* and the barges can deliver it only at the water's edge, whence it must be again transferred to cars or wagons. The banks of the river are impassable barriers.

The car, on the other hand, can take the coal from the mine and can deliver it without further handling to any point, whether on river bank or mountain top, that can be reached by a railroad track, and with proper appliances can drop it at the furnace door. To this limitation of the waterway to a single channel, open usually but part of the year, and to the unlimited ability of the railroad to reach any point at any time, is due, more than to anything else, the enormous extension of the railroad which has marked the last fifty years and the relative decline during the same time of traffic by canal and river. That the future will materially change this relation between these two classes of traffic is highly improbable.

* It is true that on the upper Ohio River and its tributaries there are at present many mines on the river bank. But these mines can only reach the outer edge of the field and must before long be either exhausted or be subject to a long and expensive underground haul that will neutralize their present advantage over the more distant mines.

OBITUARIES.

Alfred Everett Nichols.

MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

ALFRED EVERETT NICHOLS, son of Albert Franklin and Grace Eaton Nichols, was born in Lowell, Mass., September 28, 1864. Through his mother's family he traced his ancestry back to the Revolutionary period, she being a great grand-daughter of Major Zibeon Hooker, who was drum-major at the Battle of Bunker Hill. He received his education in the public schools of his native city. Soon after entering the high school he was given, during the summer vacation, a boy's position in the city engineer's office. When the fall term began he preferred, like many another boy, not to return to school. He remained in the city engineer's office for about twelve and a half years, gaining while there an experience which was of great value to him in his life work. He left the city's employ in 1893 and immediately entered his father's office in Nichols Foundry.

His father owned and managed, besides the Nichols Foundry in Lowell, a machine shop in Nashua, N. H., devoted largely to the manufacture of the Swain Turbine Water Wheel, of which he was sole owner. During a number of years Mr. Nichols was his father's associate and assistant, giving much of his time and thought to the sale and manufacture of the Swain Turbine Water Wheel. After his father retired from active business the care and responsibility devolved upon the son, who managed the business of the firm for the next ten years. Upon the death of his father in 1907, he bought from the heirs their interest in the foundry business. It was with deep regret that he felt obliged to abandon the manufacture of the Swain Turbine because of lack of sufficient capital, a business into which he had put his strongest personal interest.

The Swain water wheel is an inward and downward discharge turbine, which, under rigid tests made in 1869, gave an efficiency of 81.7 per cent. of gross power of the water at full gate; the same at seven-eighths gate, and 80.9 per cent. at three quarters gate; results, which not only were much better than those given by any other turbine, but about as good as the best results obtained to-day. This and following tests, which further em-

phasized the efficiency of this turbine, and the relatively small cost of its installment which resulted from its relatively high speed, and its economy in maintenance, led to the replacement of the Boyden and older types by the Swain Turbine. These wheels were all built with vertical shafts until about the year 1895, when the Swain Company began to install the wheels in pairs on horizontal shafts with patented central discharge draught tubes. They were also increased in capacity to double their earliest rating. The Swain wheel stands to-day as the type of turbine that contains the fundamental principles upon which all turbines are built; to it is due the greatest improvement over the Fourneyron type, and it was the model from which the Hunt, Hercules, McCormick and other modern wheels were developed. The total power of the Swain wheels in Lowell to-day is 7 000 horse-power. Mr. Nichols was much interested in the latest type of the Swain turbine and had much to do with their manufacture and erection.

He was a member of the Eliot Church, of William North Lodge of Masons, of Mt. Horeb Royal Arch Chapter and of Pilgrim Commandery Knights Templars, also of the Royal Arcanum, the New England Foundrymen's Association and of the Boston Society of Civil Engineers.

He was married, in September, 1891, to Miss Annie Goulding, of Lowell. His home life was always his main interest. He was a companion to his boy, a lover of good music, enjoyed a good book and the quiet hour at home. Throughout his difficult business experience he always had the same cheerful and pleasant manner that characterized him through life. He died July 31, 1907, after a brief illness at the seashore, where it had been his custom in the summer months to seek rest at the week's end, and to enjoy cottage life with his family and friends.

George A. Nelson,
Arthur T. Safford,
Committee.

James Dun.

Member of the Engineers' Club of St. Louis.

The late Mr. Dun was born in Chillicothe, Ohio, September 8, 1844. He graduated in the high school of that town, afterward attending a high-class private school at St. Catherines, Ontario, and later graduated from Miami University, at Oxford Ohio.

He began his railroad career as chainman in a surveying party of the Indianapolis & Cincinnati Railway, in 1866. In 1867 he became assistant engineer of the Atlantic & Pacific Railway (now the Frisco) and continued in that position until 1871, when he became assistant engineer of the Missouri Pacific, which position he held for about three years. From 1874 to 1877 he was engineer of the Union Depot in St. Louis, and upon the completion of that work entered the service of the St. Louis & San Francisco Railroad, as superintendent of bridges and buildings, and in a very short time thereafter was appointed chief engineer of that railroad, his appointment bearing the date of April, 1877. He continued in the position of chief engineer, holding for a time the position of assistant general manager in addition, until the spring of 1890, when he became chief engineer of the Atchison, Topeka & Santa Fé. In 1900 he was appointed chief engineer of the entire Santa Fé System, remaining as such until 1906, when he became their consulting engineer, holding this position at the time of his death.

Mr. Dun became a member of this Club in January, 1890, and at the time of his death was still a member. He was elected a corporate member of the American Society of Civil Engineers June 7, 1876; he was also a member of the Western Society of Engineers and other technical societies.

Your Committee has been favored with an intimate knowledge of Mr. Dun for twenty-five years. In all that time we have failed to meet one person who, knowing Mr. Dun, did not like him personally; and the better he was known, the more he was liked. His kindness, especially to the younger members of the profession, was unvarying, and nothing was too troublesome to do to oblige a friend.

His reputation as an engineer was international; it is hardly necessary to refer to his work, as the Frisco and most of the Santa Fé System are evidence, his last important work being the construction of the Belen Cut-Off in New Mexico.

The engineering profession sustains a severe loss by his death, as do his friends — that is to say, every one who knew him.

J. F. Hinckley,
C. D. Purdon,
Committee.

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THE COLLECTION AND DISPOSAL OF MUNICIPAL WASTE AND REFUSE.

BY X. H. GOODNOUGH, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Sanitary Section, January 1, 1908.]

ONE of the problems most closely affecting the health and comfort of a community is that of the collection and proper disposal of its waste and refuse. It has been the experience of the writer in connection with his regular duties, and as a member of a commission appointed by the mayor of the city of Boston to consider plans for improving the methods of municipal waste disposal in that city and the prevention of a nuisance therefrom, to investigate questions relating to the disposal of municipal wastes in various cities.

In connection with this work much information has been collected relating to the quantity of such wastes and the methods of disposal in use, and it is the purpose of this paper to describe these methods briefly and present subsequently certain facts showing the quantity and character of the city wastes now collected in the city of Boston and elsewhere.

CLASSIFICATION OF CITY WASTES.

First in importance are the wastes from dwellings and stores classified as household wastes, which consist of (*a*) garbage; (*b*) ashes; (*c*) refuse, consisting of wood, paper, rags, bottles, tin cans, broken furniture and utensils, sweepings from floors, yards, etc. The householder is required in parts of the cities of Boston and New York and in some of the other cities to keep the gar-

bage in one receptacle, ashes in another and the combustible wastes and certain other refuse in a third. A notice distributed to householders north of Massachusetts Avenue in the city of Boston makes the following classification of household waste and refuse:

CITY OF BOSTON. REFUSE DISPOSAL.

(Cards distributed to householders north of Massachusetts Avenue.

(*Reverse side.*)

Garbage.

All vegetable matter.

Sauce bottles.

Only catsup and other sauce bottles should be put into the garbage can; all other bottles into the paper barrel.

Tin cans.

Fruit, vegetable and meat cans should be put into the garbage can; other cans into paper barrel.

Ashes.

Sawdust.

Broken bottles.

Broken glass.

Broken crockery.

Floor and street sweepings.

Oyster and clam shells.

Tobacco stems.

NOTE. — Where there is a large quantity, as at a restaurant, they must be hauled by the owners.

Paper.

Bottles.	Old cloth.
Rags.	Pasteboard boxes.
Tin cans.	Old shoes.
Excelsior.	Leather and rubber scraps.
Straw.	Carpets.
Mattress.	Combustible refuse generally.

In most cities, however, only two separations are required, and combustible waste and refuse are included with the ashes and house dirt.

Next in importance to the household wastes are the wastes from markets which, in the city of Boston and other large cities, are not classified either as garbage or refuse and are disposed of separately.

Beside the wastes from houses, stores, shops, etc., there are still other large quantities of municipal wastes of various kinds. The disposal of dead animals and of slaughter-house refuse is usually, in Massachusetts at least, undertaken by rendering or fertilizer establishments operated by private parties, and the rendering establishments usually care for waste meats which constitute a small portion of the market wastes. The cleanings from streets and catch-basins form a very large item in municipal wastes. Earth from excavations and other wastes from building construction are a considerable item of city waste, and stable

manure is often included, though not in very large quantities in cities in this region.

The disposal of snow, though a troublesome problem, especially in the larger cities, is sometimes carried out in connection with other city refuse, but it does not affect seriously the problem of their disposal. It may be said in passing that officials having charge of the disposal of snow in the larger cities are looking somewhat longingly toward large sewers as an aid in the solution of that problem, and experiments in that line of disposal may be expected, in the seaboard cities at least, in the near future.

The collection and disposal of sewage, a very important municipal waste, is a problem quite apart from the disposal of other refuse, though the disposal of sludge from sewage settling tanks is sometimes included.

Methods of Disposal.

A brief glance at the history of methods of refuse disposal in use in this country is of interest as indicating the causes of present conditions and some of the difficulties to be met with in improving them, and for this purpose it is not necessary to study very deeply into ancient municipal records since practically all stages of this history are being reproduced to-day in the various towns and cities, from the small town just beginning to have a system of general collection of garbage to a great city such as Boston, for example, which expends more than three quarters of a million of dollars a year in the collection and disposal of its municipal refuse.*

The first class of refuse the disposal of which thrusts itself upon municipal authorities in a growing village or town — if we except the contents of vaults and cesspools, the disposal of which is another matter — is the kitchen waste or garbage, and the common method of disposal adopted in this part of the country at least is to feed it to swine. This method frequently produces a revenue — a very important consideration to municipal governments — and the method is rarely objectionable enough in small communities to lead to a demand for a change. In the city of Cambridge, for example, the revenue from the sale of garbage amounted, in the year 1907, to $10 564.07.

The general collection and disposal of ashes and refuse other than garbage is a matter which presents itself as a municipal problem at a later stage of city growth and is commonly not

* Not including street sweepings.

forced upon the attention of municipal authorities until the method of garbage disposal has become established. Moreover, ashes and other refuse do not constitute a source of income as garbage commonly does, nor are these materials of an offensive character like garbage. Consequently, they can be disposed of by dumping in out-of-the-way places, and as such areas are usually readily available in the towns and smaller cities, at comparatively short hauls, objection to this method of disposal of such wastes is not, usually, serious in the smaller communities.

As the cities and towns grow, however, very objectionable nuisances frequently result from this method of disposal of ashes, waste and refuse. For example, I may mention a city of about 20 000 inhabitants in which I was called upon to advise as to refuse disposal a few years ago. In this case the ashes and other refuse excepting garbage had been disposed of by dumping at many different places in low lands along the banks of a river which flowed through the city. The low lands gradually became filled to the edge of the water, and then portions of the dumps were washed away from time to time in freshets and deposited along the banks of the stream elsewhere. The result was to transform a naturally beautiful stream, the banks of which were used in many places as playgrounds, into a most unsightly nuisance.

In the larger cities longer hauls make the disposal of ashes and refuse by dumping increasingly expensive, but so long as this method is tolerated and the expense is not too great, its use continues.

Thus the methods of collection and disposal of the two most important classes of household wastes have been developed separately, and in this country, up to the present time, those classes of waste have continued as a rule to be disposed of by separate methods. With the increase in the size of a city the difficulty of disposing of the garbage for the feeding of swine increases, and with the growing demand for better sanitary conditions in recent years the objections to swine feeding as a method of garbage disposal have raised serious obstacles to the further continuance of that method.

It is worth while, however, to call attention in passing to a remarkable development of that method of garbage disposal which is found in the city of Worcester, where the garbage from a large part of the city is collected by the overseers of the poor, who maintain a municipal piggery from which a considerable income is derived. The importance of this income has thus far

been successfully urged when the health officials of that city have recommended the introduction of a sanitary method of garbage disposal.

When the disposal of garbage by feeding to swine becomes too objectionable for longer toleration, or becomes impracticable for other reasons, the next method presenting itself is usually to dump the material on land, or better, if practicable, at sea. The disposal of garbage by dumping on land, using it as a fertilizer or burying it in trenches, has not been practised very extensively in this region. The dumping of garbage at sea was begun by the city of Boston apparently not more than twenty years ago. In the beginning, moreover, the employment of this method was not extensive, for in the report of the Street Department for the year 1891 it is stated that only such of the offal as was decayed was dumped at sea, the amount so disposed of in that year being about 3 per cent. of the total quantity collected. The remainder was sold for the feeding of swine. The city of Lynn has recently reached the stage where a portion of the garbage is disposed of by dumping at sea, though the quantity thus far disposed of in that manner is not large. The garbage of the town of Hull, which includes the great summer resorts of Nantasket and its neighborhood, is also dumped at sea during the summer season.

When the further employment of methods of garbage disposal such as those herein referred to becomes impracticable, the next step is the introduction of some method of destruction. There are many of these methods, but they may be readily divided into two general classes, both of which apply to garbage only: one, burning or cremation; and the other, reduction. The former method seeks simply to reduce the garbage to inoffensive clinker or ashes, while the reduction method is designed to extract from the garbage materials of commercial value which will reduce the cost of disposal.

Garbage crematories have been installed in many cities in this country, but in a very large number of cases they have been reported as unsatisfactory or have later been superseded by other designs or by a different method. The crematories which I have seen in American cities are furnaces operated under ordinary draft, usually with coal as a fuel. A recent examination of a furnace of this kind used, in this case, for the burning of market wastes, showed serious defects from a sanitary point of view. The heat was not great enough to destroy the odors at all times, and the heavy gases generated in the furnace, though discharged

through a tall chimney, fell to the ground and were very offensive. The refuse was not completely burned, and the charred mass discharged from the furnace containing unburned material was offensive and much of it had to be reburned. Coal was being used, though not in large quantities, as the wastes contained much combustible material. The operation of this furnace in or near a populated district in the manner in which it was being operated when examined would be intolerable.

The reduction process is used chiefly in the larger cities and is the method employed in Boston, New York, Cleveland and elsewhere. The method is designed to recover from the garbage, while effecting its satisfactory disposal, materials of commercial value as an offset to the cost of disposal. By this method the garbage is cooked with steam for several hours in iron cylinders set vertically, each having a capacity of several tons. After cooking, the grease is drawn out, barreled and sold, the price obtained recently being apparently from three to four cents per pound. The tankage is pressed, dried and ground and sold for fertilizer. This method of garbage disposal was introduced in Boston in 1898, when a contract was made with a private company to dispose of the city garbage, under which the city pays $52 400 a year for this work. Concerning the introduction of this method the following statement is made in the report of the superintendent of streets for the year 1898:

"A more sanitary method of disposing of the city offal has long been under consideration, and as a result of investigations made by a committee appointed by the city government a contract for a term of ten years was made with the New England Sanitary Product Company in January, 1898, by the provisions of which nearly 77 per cent. of the collection is conveyed to an isolated point within the city limits and treated by a method known as the 'Improved Arnold Process,' which disposes of it n an unobjectionable manner."

In that year (1898) 59 per cent. of the garbage of the city of Boston was sold for feeding swine and the remainder dumped at sea. The new garbage plant has received and disposed of a gradually increasing portion of the offal of the city since it was put into operation in the latter part of 1898 or the early part of 1899, and it is stated that after March 4, 1899, the sale of offal to farmers entirely ceased and the dumping of offal at sea was discontinued. Apparently this refers to the offal of the downtown districts, since offal from some of the suburban districts is still sold for the feeding of swine, though the quantity so disposed of is now very small.

It is interesting to note that, notwithstanding the expectation of the department as quoted above, a serious nuisance resulted at the first location of the reduction plant,— at Calf Pasture in Dorchester, — and the location was subsequently changed to Spectacle Island in Boston Harbor. Even here complaints of objectionable odors from these works have appeared in the newspapers from time to time. The contract with the garbage disposal company runs until 1912.

One other city in Massachusetts (New Bedford) employs this method of garbage disposal. The process used in that city is somewhat different, though the products are similar. The works are located in a sparsely settled region two or three miles from the city proper.

The disposal of garbage has not been made as yet commercially profitable, at least to the cities in which it is used. The works are, in nearly all cases, owned by private companies subsidized by the city, and no definite information is available as to the cost of construction or maintenance, or the income obtained. It is evident, however, that the best economy with such plants is attained where they are operated in large units, and the use of this method of garbage disposal usually involves long hauls in order that all of the material may be disposed of at a single plant. About four years ago the city of Cleveland purchased the garbage reduction plant of that city and has greatly enlarged and improved it, so that it will soon be practicable to learn something of the economy of this method of garbage disposal in a large city. It should be added, however, that the Cleveland plant is situated in an isolated locality, where objections on sanitary grounds are not likely to be raised.

Like cremation plants, plants for reduction of garbage as thus far developed have been objectionable on account of offensive odors therefrom, and the waste water from such establishments contains much offensive organic matter and is likely to create a nuisance unless provision is made for its satisfactory disposal.

It is evident that if these plants are to continue in use in some of the places in which they have been installed, more efficient provision for the prevention of nuisance will have to be made.

Referring again to the disposal of ashes and other household wastes and refuse, we have seen that the usual method is to dump them upon the most convenient area of land available for the purpose. In the smaller cities this method of disposal is generally

the least expensive one available, but in larger cities longer hauls to available dumping places increase the cost, and the length of haul is, as a rule, a constantly increasing one. In the densely populated parts of the city of Boston, for example, cartage to dumps on land long ago became very expensive, and for many years much of the waste and refuse in the downtown districts of the city has been dumped at sea. The fouling of the shores of the bay resulting from this practice led to a change in the dumping place by carrying the material farther to sea, and subsequently to the installation of the garbage plant to which reference has already been made. It was still found necessary, however, to remove from the mass of refuse dumped at sea a larger proportion of the material likely to float, and the plan finally selected for accomplishing this result was to require the householder in the districts from which the refuse is disposed of at sea to keep combustible waste separate from other materials and to burn the combustible waste so that the ashes only would require disposal.

For burning the combustible waste an incinerator plant was erected in 1899 and is in operation at the present time. This plant, like the garbage plant, is owned by a private company subsidized by the city and operated under a contract which in this case will terminate in 1908. Under this contract the city delivers to the plant the combustible wastes and refuse from certain districts free from garbage and certain other objectionable matters and pays the incinerator company the sum of $5 500 per year. The city also pays all taxes, rent of land, water rates, etc. The waste is picked over for salable material, sorted out, and the remainder burned. The ashes and incombustible matters are deposited in the city dumping scows and dumped at sea. As in the case of the garbage plant, information as to the cost of operation and economies resulting therefrom is lacking, but there is no reason to doubt that the income from the sale of merchantable material is a very considerable one. Plants similar to this are in operation in the city of New York, and the method is to be tried in other cities.

These furnaces are adapted only to the burning of paper, wood and light combustible wastes generally, and are not, or at least if properly designed and maintained, need not, be objectionable if located in populous districts. An attempt has been made in some cases to utilize the heat from such plants for making steam, and a small amount of power has been secured in this way at several of the plants. The power produced does not, however, constitute a considerable economy in any case.

Natural draft is used, the heat attained is not great and it is very doubtful whether the power obtainable can be made to produce a considerable income from the operation of such plants.

Clean ashes unmixed with other wastes may be dumped upon land and used for filling or dumped into the sea without serious objection from a sanitary point of view. The object of the third separation, so called, is to keep separate from the ashes and other wastes those materials which would be objectionable or unsightly if deposited upon inland dumps, or which might float ashore if dumped at sea; but the separation of combustible materials from the ashes and other wastes in the cities in which it is enforced does not extend to all parts of the city, nor is the separation thorough in the districts in which it is enforced.

In the city of New York, as already stated, a part of the combustible waste is disposed of by burning in incinerator plants. Most of the remainder is now disposed of upon dumps near the shores of the harbor remote from the city, and little or none is now dumped into the sea. At many of the shipping points for city waste the combustible material is baled and when deposited upon the dumps does not create objection in the neighborhood, but this is a costly and troublesome method for the disposal of such wastes.

In the city of Boston, even in the districts in which the third separation is enforced, a great amount of combustible waste is still discharged, either upon the dumps, to be blown about the neighborhood, or into the sea, to float to neighboring shores. Observations of the results of the third separation now provided for in the part of the city north of Massachusetts Avenue show that the result at present is a very unsatisfactory one. Observations of the number and character of the loads of material classed as ashes have been made at Fort Hill Wharf — the principal shipping point of such wastes in the city of Boston — during the past year, which will probably give a fair indication of the efficiency of the third separation. Observations made on June 10, 1907, show that out of 177 loads of ashes and house dirt dumped into the scows at that wharf on that date, only 20 loads, or 11 per cent., consisted wholly of ashes. The remainder was made up in varying proportions — sometimes wholly — of paper and other refuse. A similar study on June 22, 1907, showed that out of 194 loads, 14, or a little over 7 per cent., were composed wholly of ashes, while of the remainder, 113, or 63 per cent., were more than half paper and

other refuse. Further observations made on December 9 showed that, out of 393 loads, 118, or 30 per cent., were all ashes, while another 30 per cent. was more than half paper and combustible waste.

These facts show that the third separation, as it is called, has not thus far been thorough in the districts in which it has been tried, and it is evident that it will be extremely difficult of general enforcement, if not impracticable. A similar condition exists in the city of New York.

There is no doubt that the introduction of the incinerator plant and the separation of a part of the combustible materials from the other wastes in parts of the city of Boston have diminished the nuisance resulting from the dumping of city wastes at sea, but the aggregate quantity of combustible waste and refuse still disposed of by dumping at sea or upon land is constantly increasing and must continue to increase in the future, as the city grows, and become objectionable, unless further provision is made for its satisfactory disposal.

So far as the disposal of market wastes is concerned, where any other method has been provided than dumping, the method employed has been either to include them with the garbage, where they would seem properly to belong, or to provide for their separate disposal by burning.

This brief review of the present methods of refuse disposal and the conditions resulting therefrom indicates that at the present time the tendency in American cities is to separate household wastes into three distinct classes: (1) garbage, (2) ashes, and (3) combustible waste and refuse; and to dispose of these different classes of waste by separate and distinct methods, — the garbage by burning in furnaces constructed for the purpose or by reduction for the recovery of salable by-products; the ashes and house and store dirt by dumping in available places on land or at sea; and the combustible wastes by incineration in simple furnaces designed for that purpose, with the recovery of certain materials picked from the waste and an attempt to secure power by utilizing the heat produced.

Combustible wastes have not thus far, however, been separated efficiently from the ashes and the difficulty of enforcing complete separation is regarded in some places as insuperable. It is important to note in this connection that in one city where there is no third separation a furnace is being erected for the burning of the ashes and combustible waste without any attempt at separation. This plan, if successful, promises a

change in method and may indicate that the attempt at a third separation will not be carried to a greater development than it has thus far reached. There are other indications also that the value of the third separation may not be sufficient to warrant its further development.

Taken as a whole, the methods of garbage and refuse disposal in American cities are inefficient and unsatisfactory, and many cities are investigating the subject, and new methods are being tried. Unfortunately for the satisfactory solution of these problems they are still commonly referred for investigation to committees of city governments, made up usually of men who lack the necessary training and experience to collect the necessary facts and study the problems intelligently, and many failures and much waste of money are the necessary results. The disposal of city waste and refuse is an engineering problem, and until they are treated as such satisfactory progress in their solution is unlikely.

If we now turn to the methods of refuse disposal employed in other countries, and especially in the British Isles, whose people and problems in municipal sanitation are so like our own, we find a very different condition. The English cities appear to have to some extent traversed the road over which American cities are now passing in respect of the disposal of municipal waste; but there has been a very great change in methods in recent years. The modern method of disposal of household wastes in English cities is, in brief, to collect all of those wastes — garbage, ashes, house dirt and combustible materials — in a single receptacle and to dispose of them by cremation.

The essential difference between the English cremation plants and the garbage furnaces and incinerators in use in this country is the employment in the English plants of forced draft and the attainment of temperatures in the furnaces of from 1500 degrees to 2000 degrees fahr., and even higher. The general result of the operation of these plants appears to be that they are efficient and satisfactory from a sanitary point of view and not seriously burdensome in cost of construction and operation.

Only one of these plants has thus far been erected in this region, and a brief description of it may be of interest as showing one of the types most commonly and successfully used for the destruction of municipal wastes and refuse in England.

This plant is located at Westmount, a suburb of the city of Montreal, having a population of about 12 000, bearing much the same relation to the city of Montreal that the town of Brook-

line does to the city of Boston. This destructor is a furnace containing three grates, each 5 ft. square, in a single chamber. The refuse is fed to this furnace at the top, and each grate is charged from a separate feed-hole. Steam jet blowers force air drawn from the building under the grates. From the cells the smoke and gases pass to a combustion chamber, so-called, to effect their thorough combustion, and the hot air passes from the combustion chamber to a boiler and thence to the chimney. On the way to the chimney the heat of the gases is reduced by heating the air used by the blowers.

This plant is said to handle about 30 tons of mixed refuse — garbage, ashes, etc. — per day and is capable of handling a somewhat larger quantity. The material is reduced to ashes and clinker, the volume of which is about 30 per cent. of that supplied to the furnace. The clinker and ashes are used in part for filling for sidewalks and the material not used is dumped not far from the destructor. No fuel other than that contained in the refuse is necessary in this destructor, except for starting fires in the beginning, since the three grates are side by side, and when one is charged coals from an adjacent grate are used for the purpose. The degree of heat attained in this furnace is said to be at times from 2700 degrees to 2800 degrees. The steam generated in the boiler is used in furnishing power for an electric lighting plant adjacent to the destructor.

While this is the only destructor of the type in use in this part of the country, it should be noted here that at Staten Island a destructor of this class is now being built for the cremation of refuse in the Borough of Richmond, which is described by Mr. J. T. Fetherston, superintendent of streets, and an engineer, in a paper recently presented to the American Society of Civil Engineers.

The Montreal destructor was constructed by Meldrum, of Manchester, and the one at Staten Island is being built by Heenan & Froude. As I have already stated, while these destructors vary radically from those hitherto in use in the United States, chiefly on account of the very much higher temperatures maintained, there are very considerable differences between the different types which I will not undertake to discuss here.

Very considerable economies are claimed in the use of the English destructors, the principal one being heat, which is used for power. The English refuse apparently has a value of at least 10 per cent. of that of coal and possibly a materially higher value. The clinker resulting from cremation also appears to

have a value in some places for use in making concrete, from which sidewalks and similar structures and even buildings are made. The power developed at many of the plants in England is used for the pumping of sewage or of water or for generating electricity for lighting and other purposes.

There has been a great amount of discussion as to whether the English destructors would be found practicable in this country, and it has been urged that the character of our refuse is very different from that of English cities, and analyses have been adduced to show this difference.

Representative samples of such materials as compose city waste and refuse are exceedingly difficult to collect, and comparative analyses by different collectors and analysts may be very misleading. While it is maintained by some that there is a very considerable difference between the character of the wastes of the English cities and that of our own, others experienced in such matters have been unable to see that such material difference exists.

The only satisfactory way in which the question of the practicability of the use of the English destructors for the disposal of municipal wastes in this country will be satisfactorily determined will be by actual trials, and the results of the operation of the plants at Montreal and in the Borough of Richmond will be of great value in the information they give as to the efficiency and cost of operation of such works.

It has been for many years and is still urged by those not too familiar with questions of sewage disposal that sewage contains material of great potential value as a fertilizer and that by discharging it into rivers or the sea, or disposing of it by methods designed simply to prevent a nuisance, very valuable material is being wasted. That there is material of potential value as a fertilizer in sewage no one would deny, but hitherto no one has succeeded in devising a plan which will dispose of sewage satisfactorily and obtain any material income therefrom. A considerable quantity of apparently good fertilizing material is separated from sewage by processes of sedimentation at our various sewage disposal works, but it is rarely possible to sell this material for any price and sometimes impossible to give it away.

Municipal waste also, and doubtless to a considerably greater degree than sewage, contains materials of commercial value, and there is no doubt that a very considerable income could be made by any large city by letting out the privilege of

picking over this waste. This has been done in some of our cities. In the case of garbage, especially, is it urged that commercially valuable products in large quantity can be derived from its reduction or distillation; but it does not appear that the materials recovered have thus far been of sufficient value to make the handling of the garbage of a city commercially valuable unless the city pays for the work.

In refuse disposal, as in sewage disposal, the solving of the sanitary problem comes first, and it is essential that a method be selected which will not produce a nuisance. If this condition shall be fulfilled, any economies resulting from the method used will be a gain.

Methods of Collection and Disposal of Refuse in the City of Boston.

The collection and disposal of municipal refuse in the city of Boston is carried out by the Sanitary Department.

The city is divided into ten districts, the boundaries of which follow in part the natural topographic divisions and in part the original boundaries of former municipalities which have been annexed to the city at various times. These districts and the population of each are as follows:

		Population.
District No. 1 . . .	South Boston . . .	71 000
District No. 2 . . .	East Boston	51 000
District No. 3 . . .	Charlestown	40 000
District No. 4 . . .	Brighton	22 000
District No. 5 . . .	West Roxbury . . .	37 000
District No. 6 . . .	Dorchester	89 000
District No. 7 . . .	Roxbury	109 000
District No. 8 . . .	South End	103 000
District No. 9 . . .	Back Bay	
District No. 10 . . .	North and West Ends	73 000
Total		595 000
Population, census of 1905		595 380

Classification of Municipal Waste in the City of Boston.

In the city of Boston the principal municipal wastes requiring disposal fall into six general classes:

1. Ashes, including house and store dirt.
2. House offal.
3. Combustible waste and rubbish.
4. Market refuse.
5. Street cleanings.
6. Cesspool and catch-basin cleanings.

With the exception of No. 3, the above divisions apply to all parts of the city. The third item, combustible waste and refuse, is known as the third separation and represents an attempt to keep separate from the other wastes materials which if dumped into the harbor are likely to float ashore. It applies to that portion of the city lying north of Massachusetts Avenue, but does not include Charlestown and East Boston.

Collection of Wastes.

House Dirt and Ashes. — At the present time 213 single and 20 double carts are used for collecting house dirt and ashes in all parts of the city. All of the carts are of wood, are fitted with canvas covers and so constructed that their contents can be readily dumped. This class of material is collected by the employees of the Sanitary Department except in the districts of Dorchester and West Roxbury. In Dorchester all this work is done by contractors, while in West Roxbury less than one third of the total quantity of ashes is collected by contractors.

House Offal. — About 138 carts are used for collecting house offal throughout the city. Fifty-seven are iron — 40 of which have a capacity of about 50 cu. ft. each, while 17 have a capacity of about 80 cu. ft. each. Of the 81 wooden carts in use, 7 are large carts, having a capacity of about 80 cu. ft. and the remainder are small ones, having a capacity of 40 cu. ft. All of the carts, with the exception of those last mentioned — the small wooden ones — are covered with wooden or canvas covers so arranged that the carts can be readily dumped. The small wooden carts are emptied by shoveling out the offal.

Waste and Rubbish. — The collection of this class of refuse is done entirely by employees of the Sanitary Department, most of the material collected being delivered at an incinerator plant on Hecht Wharf near Atlantic Avenue. There are 56 carts used in this work. Thirty-four of these have a capacity of 109 cu. ft. each, while the remainder will hold double this amount. All the carts are of wood and are fitted with canvas covers. They are not so arranged that they can be dumped. The material has to be removed by hand through doors in the rear of the carts.

Street Cleanings. — Street cleanings are collected by the Street Department, which uses 104 carts in this work. They have a capacity of about 50 cu. ft. each, are made of wood and are not covered, Sixty-eight of the carts are owned by the city and the remainder are hired. Part of the work — that in

Brighton and West Roxbury — is in charge of the Street Paving Department.

Cesspool and Catch-Basin Cleanings. — Cesspool and catch-basin cleanings are collected by the Sewer Department, and during the year 1906, 42 carts — 22 single and 20 double — were in use at one time or another on this work. Of the single teams, 16 belong to the city and 6 were hired from contractors, while of the double teams, 1 is owned by the city and 19 by contractors. The double teams are all of wood and fitted with wooden covers, but a part of the single teams owned by the city are made of steel in the form of a half cylinder, fitted with covers so arranged that the material can be easily dumped. The half-cylinder carts have a capacity of about 30 cu. ft., while the larger wooden carts hold 35 cu. ft.

Frequency of Collection.

House dirt and ashes are collected either once or twice a week during the winter time and only once a week in summer. Paper and rubbish are collected chiefly on Mondays and Thursdays, in the portion of the city north of Dover Street, and on Wednesdays and Saturdays in the remaining districts. In the districts of the city where there is no third separation, such material is mixed with the ashes.

House offal is removed from dwelling houses, as a rule, once a week in the winter and twice a week in summer, except in the Back Bay, where it is removed twice a week throughout the entire year, while in the business portion of the city — Districts 8, 9 and 10 — the large hotels and restaurants are visited daily.

Quantity of Waste and Refuse of Various Kinds Collected in the City of Boston.

A careful record is kept by the Sanitary Department of the total number of loads of materials of various kinds collected and disposed of throughout the city on each day in the year, and from these records as a basis an estimate has been prepared of the total volume and weight of refuse of various kinds collected in the city in the year 1906. As a basis for estimating the volume and weight of the various materials, numerous carts of various capacities and of different materials have been measured and weighed in different months of the past year. With these results, and the records of the Sanitary Department as a basis, the following table has been prepared:

TABLE No. 1. — BOSTON REFUSE DISPOSAL.

TABLE SHOWING AVERAGE WEEKLY AND DAILY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM THE **Entire City** DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (Population, 1905, 595 380.)

		Cubic Feet.		Tons.			Cubic Feet.		Tons.	
		Average Weekly.	Average Daily.*	Average Weekly.	Average Daily.*		Average Weekly.	Average Daily.*	Average Weekly.	Average Daily.*
January	Ashes	431 800	78 510	10 797	1 963	July	252 400	45 892	6 311	1 148
	Rubbish	62 843	11 426	247	45		54 728	9 950	215	39
	Garbagc	67 550	12 282	1 437	261		57 300	10 418	1 220	222
	Market refuse	6 030	1 096	128	23		2 410	438	52	9
	Total	568 223	103 314	12 609	2 292		366 838	66 698	7 798	1 418
February	Ashes	446 250	81 137	11 156	2 028	August	263 700	47 946	6 592	1 198
	Rubbish	58 838	10 698	231	42		57 247	10 408	225	41
	Garbage	65 300	11 873	1 391	253		62 850	11 428	1 340	244
	Market refuse	6 360	1 156	136	25		6 980	1 268	149	27
	Total	576 748	104 864	12 914	2 348		390 777	71 050	8 306	1 510
March	Ashes	439 300	79 872	10 983	1 997	September	258 900	47 072	6 474	1 177
	Rubbish	61 716	11 222	243	44		56 833	10 334	224	41
	Garbage	64 750	11 772	1 378	250		61 900	11 254	1 319	239
	Market refuse	7 050	1 282	150	28		7 920	1 440	169	30
	Total	572 816	104 148	12 754	2 319		385 553	70 100	8 186	1 487
April	Ashes	416 250	75 682	10 406	1 892	October	295 850	53 792	7 396	1 344
	Rubbish	62 784	11 415	247	45		62 130	11 296	244	44
	Garbage	61 250	11 136	1 305	237		66 400	12 072	1 414	257
	Market refuse	6 430	1 169	137	25		6 780	1 232	144	26
	Total	546 714	99 402	12 095	2 199		431 160	78 392	9 198	1 671
May	Ashes	366 500	66 636	9 162	1 666	November	325 150	59 118	8 130	1 478
	Rubbish	60 212	10 948	237	43		60 146	10 936	236	43
	Garbage	60 700	11 036	1 294	235		62 100	11 290	1 323	240
	Markct refuse	7 250	1 318	154	28		6 160	1 120	132	24
	Total	494 662	89 938	10 847	1 972		453 556	82 464	9 821	1 785
June	Ashes	279 900	50 890	6 999	1 272	Deeember	397 850	72 336	9 947	1 809
	Rubbish	59 873	10 886	236	43		61 422	11 168	241	44
	Garbage	61 400	11 164	1 309	238		66 650	12 118	1 421	258
	Market refuse	7 180	1 306	153	28		5 960	1 084	127	23
	Total	408 353	74 246	8 697	1 581		531 882	96 706	11 736	2 134
						Average: Ashes	347 820	63 240	8 696	1 581
						Rubbish	59 899	10 891	235	43
						Garbage	63 179	11 487	1 340	244
						Market refuse	6 375	1 159	136	25
						Total	477 273	86 777	10 413	1 893

* $5\frac{1}{2}$ days per week.
1 cu. yd. ashes = 1 350 lb.
1 ,, rubbish = 212 ,,
1 ,, garbage = 1 150 ,,
1 ,, market refuse = 1 150 ,,

The total quantity for any month can be obtained approximately by multiplying the average daily quantity, as given above, by 24.

In the next table are given the monthly variations in the amounts of the principal classes of refuse collected in the entire city during the year ending April 18, 1907. This table shows that the quantity of ashes, for example, collected in January and February is a little less than twice the quantity collected in the warmer summer months. The house offal apparently varies little in quantity from month to month.

Quantity of Refuse Collected in Certain Districts in the City of Boston.

As already stated, the Sanitary Department has found it convenient to divide the city into districts, following in part topographical lines and in part the lines of former municipalities annexed to the city many years ago. It has been practicable from the records of the department to determine the quantity of waste and refuse of various kinds collected in each district, and the result is of much interest in connection with the problem of waste disposal.

The different districts into which the city is divided vary greatly in character. South Boston, East Boston and Charlestown are for the most part closely built up and are densely populated. In each of those districts, and especially in East Boston, there is a large extent of water front used for shipping and for general commercial purposes, and a considerable amount of manufacturing is carried on in all these districts. The North and West Ends are very densely populated, largely by foreigners of various nationalities. The district includes much of the business portion of the city, the principal wharves and markets and many hotels. The South End is mainly a densely populated residential district. The Back Bay includes numerous hotels and the best class of dwelling houses in the city. Roxbury is in part residential, but contains in its lower portions many factories and a dense population. Brighton, Dorchester and a large part of West Roxbury are suburban in character, comparatively sparsely populated and have little or no manufacturing within their limits.

In the following tables are given the average weekly quantities of waste of various kinds collected in each of the districts of the city in the year 1906, together with the percentage or ratio of each class of waste to the total quantity of wastes. The total for each month is not kept in the records of the Street Department, but can be obtained approximately from these tables by multiplying the average weekly quantity as given by 4.3.

TABLE No. 2.— BOSTON REFUSE DISPOSAL. SHOWING AVERAGE WEEKLY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM **Entire City** DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (Population, 1905, 595 380.)

		Cubic Feet.		Tons.				Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	431 800	75.9	10 797	6.60	85.6	July	252 400	68.8	6 311	3.86	81.0
	Rubbish	62 843	11.1	247	.45	2.0		54 728	14.9	215	.13	2.8
	Garbage	67 550	11.9	1 437	.88	11.4		57 300	15.6	1 220	.75	15.6
	Market refuse	6 030	1.1	128	.08	1.0		2 410	.7	52	.03	.6
	Total	568 223	100.0	12 609	7.71	100.0		366 838	100.0	7 798	4.77	100.0
February	Ashes	446 250	77.4	11 156	6.81	86.3	August	263 700	67.5	6 592	4.02	79.4
	Rubbish	58 838	10.2	231	.14	1.8		57 247	14.6	225	.14	2.7
	Garbage	65 300	11.3	1 391	.85	10.8		62 850	16.1	1 340	.82	16.1
	Market refuse	6 360	1.1	136	.08	1.1		6 980	1.8	149	.09	1.8
	Total	576 748	100.0	12 914	7.88	100.0		390 777	100.0	8 306	5.07	100.0
March	Ashes	439 300	76.7	10 983	6.71	86.1	September	258 900	67.2	6 474	3.95	79.0
	Rubbish	61 716	10.8	243	.15	1.9		56 833	14.7	224	.14	2.8
	Garbage	64 750	11.3	1 378	.84	10.8		61 900	16.1	1 319	.81	16.2
	Market refuse	7 050	1.2	150	.09	1.2		7 920	2.0	169	.10	2.0
	Total	572 816	100.0	12 754	7.79	100.0		385 553	100.0	8 186	5.00	100.0
April	Ashes	416 250	76.1	10 406	6.36	86.1	October	295 850	68.6	7 396	4.51	80.3
	Rubbish	62 784	11.5	247	.15	2.0		62 130	14.4	244	.15	2.7
	Garbage	61 250	11.2	1 305	.80	10.8		66 400	15.4	1 414	.86	15.4
	Market refuse	6 430	1.2	137	.08	1.1		6 780	1.6	144	.09	1.6
	Total	546 714	100.0	12 095	7.39	100.0		431 160	100.0	9 198	5.61	100.0
May	Ashes	366 500	74.1	9 162	5.60	84.5	November	325 150	71.6	8 130	4.98	82.8
	Rubbish	60 212	12.2	237	.15	2.2		60 146	13.3	237	.15	2.4
	Garbage	60 700	12.3	1 294	.79	11.9		62 100	13.7	1 323	.81	13.5
	Market refuse	7 250	1.4	154	.09	1.4		6 160	1.4	132	.08	1.3
	Total	494 662	100.0	10 847	6.63	100.0		453 556	100.0	9 822	6.02	100.0
June	Ashes	279 900	68.6	6 999	4.28	80.4	December	397 850	74.8	9 947	6.07	84.7
	Rubbish	59 873	14.7	236	.15	2.7		61 422	11.5	241	.15	2.1
	Garbage	61 400	15.0	1 309	.80	15.1		66 650	12.5	1 421	.87	12.1
	Market refuse	7 180	1.7	153	.09	1.8		5 960	1.2	127	.08	1.1
	Total	408 353	100.0	8 697	5.32	100.0		531 882	100.0	11 736	7.17	100.0
Average	Ashes							347 821	72.3	8 696	5.31	83.0
	Rubbish							59 898	12.8	236	.15	2.3
	Garbage							63 179	13.5	1 346	.82	13.3
	Market refuse							6 376	1.4	136	.08	1.4
	Total							477 274	100.0	10 414	6.36	100.0

* $5\frac{1}{2}$ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 3. — BOSTON REFUSE DISPOSAL. Showing Average Weekly Quantities (Cu. Ft. and Tons) of Refuse Collected from **South Boston** (District No. 1) during Each Month of the Year, May, 1906, to April, 1907. (Population, 1905, 71 000.)

		Cubic Feet.		Tons.				Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	31 900	85.5	798	3.87	89.3	July	20 550	81.8	514	2.49	86.1
	Refuse	1 134	3.0	4	.02	.4		872	3.4	3	.01	.5
	Garbage	4 300	11.5	92	.44	10.3		3 750	14.8	80	.39	13.4
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	37 334	100.0	894	4.33	100.0		25 172	100.0	597	2.89	100.0
February	Ashes	31 450	86.5	786	3.81	89.6	August	21 450	80.5	536	2.60	84.9
	Rubbish	654	1.8	2	.01	.2		872	3.3	3	.01	.4
	Garbage	4 200	11.7	89	.43	10.2		4 350	16.2	93	.45	14.0
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.7
	Total	36 304	100.0	877	4.25	100.0		26 672	100.0	632	3.06	100.0
March	Ashes	32 050	86.5	801	3.88	89.9	September	19 700	79.3	493	2.39	83.9
	Rubbish	872	2.4	3	.01	.3		872	3.4	3	.01	.5
	Garbage	4 100	11.1	87	.42	9.8		4 350	17.3	93	.45	15.6
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	c.0
	Total	37 022	100.0	891	4.31	100.0		24 922	100.0	589	2.85	100.0
April	Ashes	28 200	85.8	705	3.42	89.6	October	22 300	81.4	558	2.71	85.7
	Rubbish	.926	2.8	4	.01	.4		872	3.2	3	.01	.4
	Garbage	3 700	11.4	79	.38	10.0		4 250	15.4	91	.49	13.9
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	32 826	100.0	788	3.81	100.0		27 422	100.0	652	3.21	100.0
May	Ashes	28 000	82.9	700	3.39	89.2	November	20 450	81.2	511	2.48	85.7
	Rubbish	2 224	6.6	8	.04	1.2		872	3.4	3	.01	.5
	Garbage	3 550	10.5	76	.37	9.6		3 900	15.4	83	.40	13.8
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	33 774	100.0	784	3.80	100.0		25 222	100.0	597	2.89	100.0
June	Ashes	19 200	78.8	480	2.33	84.4	December	29 250	85.0	731	3.54	88.6
	Rubbish	1 177	4.8	4	.02	.7		872	2.5	3	.01	.3
	Garbage	4 000	16.4	85	.41	14.9		4 300	12.5	92	.45	11.1
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.70
	Total	24 377	100.0	569	2.76	100.0		34 422	100.0	826	4.00	100.0
Average	Ashes							25 375	82.9	634	3.08	87.2
	Rubbish							1 018	3.4	4	.01	.5
	Garbage							4 063	13.7	87	.42	12.3
	Market refuse							0	0.0	0	0.00	0.0
	Total							30 456	100.0	725	3.51	100.0

* 5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 4. — BOSTON REFUSE DISPOSAL. Showing Average Weekly Quantities (Cu. Ft. and Tons) of Refuse Collected from East Boston (District No. 2) during Each Month of the Year, May, 1906, to April, 1907. (Population, 1905, 51 000.)

Month		Cubic Feet. Average Weekly.	Cubic Feet. Per Cent.	Tons. Average Weekly.	Tons. Lb.* per Capita per Day.	Tons. Per Cent.
January	Ashes	23 350	78.9	584	4.13	81.0
	Rubbish	......	.....	......	....	.....
	Garbage	6 250	21.1	133	0.94	19.0
	Market refuse	0	0.0	0	0.00	0.0
	Total	29 600	100.0	717	5.07	100.0
February	Ashes	25 250	80.2	631	4.47	82.7
	Rubbish	......	.....	......	....	.....
	Garbage	6 200	19.8	132	0.93	17.3
	Market refuse	0	0.0	0	0.00	0.0
	Total	31 450	100.0	763	5.40	100.0
March	Ashes	24 700	80.6	617	4.36	82.8
	Rubbish	......	.....	......	....	.....
	Garbage	6 000	19.4	128	0.91	17.2
	Market refuse	0	0.0	0	0.00	0.0
	Total	30 700	100.0	745	5.27	100.0
April	Ashes	24 200	80.1	605	4.28	82.5
	Rubbish	......	.....	......	....	.....
	Garbage	6 000	19.9	128	0.91	17.5
	Market refuse	0	0.0	0	0.00	0.0
	Total	30 200	100.0	733	5.19	100.0
May	Ashes	30 500	83.4	762	5.40	85.6
	Rubbish	......	.....	......	....	.....
	Garbage	6 000	16.6	128	0.90	14.4
	Market refuse	0	0.0	0	0.00	0.0
	Total	36 500	100.0	890	6.30	100.0
June	Ashes	20 950	77.8	524	3.71	80.4
	Rubbish	......	.....	......	....	.....
	Garbage	6 000	22.2	128	0.90	19.6
	Market refuse	0	0.0	0	0 00	0.0
	Total	26 950	100.0	652	4.61	100.0

Month		Cubic Feet. Average Weekly.	Cubic Feet. Per Cent.	Tons. Average Weekly.	Tons. Lb.* per Capita per Day.	Tons. Per Cent.
July	Ashes	20 000	78.0	500	3.54	79.4
	Rubbish	......	.....	......	....	....
	Garbage	6 050	22.0	129	0.91	20.6
	Market refuse	0	0.0	0	0.00	0.0
	Total	26 050	100.0	629	4.45	100.0
August	Ashes	20 050	78.0	501	3.54	79.6
	Rubbish	......	.....	......	....	.....
	Garbage	6 000	22.0	128	0.91	20.4
	Market refuse	0	0.0	0	0.00	0.0
	Total	26 050	100.0	629	4.45	100.0
September	Ashes	18 450	75.4	461	3.26	78.3
	Rubbish	......	.....	......	....	.....
	Garbage	6 000	24.6	128	0.90	21.7
	Market refuse	0	0.0	0	0.00	0.0
	Total	24 450	100.0	589	4.16	100.0
October	Ashes	19 400	74.6	485	3.43	77.5
	Rubbish	......	.....	......	....	.....
	Garbage	6 600	25.4	141	1.00	22.5
	Market refuse	0	0.0	0	0.00	0.0
	Total	26 000	100.0	626	4.43	100.0
November	Ashes	20 350	77.1	509	3.60	80.0
	Rubbish	......	.....	......	....	.....
	Garbage	6 000	22.9	128	0.91	20.0
	Market refuse	0	0 0	0	0.00	0.0
	Total	26 350	100.0	637	4.51	100.0
December	Ashes	21 300	76.6	533	3.77	79.4
	Rubbish	......	.....	......	....	....
	Garbage	6 500	23.4	138	0.98	20.6
	Market refuse	0	0.0	0	0.00	0.0
	Total	27 800	100.0	671	4.75	100.0
Average	Ashes	22 375	78.4	559	3.95	80.8
	Rubbish	....	....	......	...	.....
	Garbage	6 133	21.6	131	0.94	19.2
	Market refuse	0	0.0	0	0.00	0.0
	Total	28 508	100.0	690	4.89	100.0

* 5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 5. — BOSTON REFUSE DISPOSAL. Showing Average Weekly Quantities (Cu. Ft. and Tons) of Refuse Collected from **Charlestown** (District No. 3) during Each Month of the Year, May, 1906, to April, 1907. (Population, 1905, 40 000.)

		Cubic Feet.		Tons.				Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes (b)	22 800	89.7	570	5.18	91.1	July	15 450	82.3	386	3.51	87.4
	Rubbish	.....	....	.....	....	.....		872	4.7	3.5	.03	.8
	Garbage	2 650	10.3	56	.51	8.9		2 450	13.0	52	.47	11.8
	Market refuse	0	0.0	0	0.0	0.0		0	0.0	0.	0.00	0.0
	Total	25 450	100.0	626	5.70	100.0		18 772	100.0	441.5	4.01	100.0
February	Ashes (b)	20 450	89.3	511	4.65	90.8	August	15 600	81.2	390	3.54	86.3
	Rubbish	.....	....	.....	....	.....		872	4.5	3.5	.03	.7
	Garbage	2 450	10.7	52	.47	9.2		2 750	14.3	59	.54	13.0
	Market refuse	0	0.0	0	0.0	0.0		0	0.0	0.	0.00	0.0
	Total	22 900	100.0	563	5.12	100.0		19 222	100.0	452.5	4.11	100.0
March	Ashes (b)	22 550	90.4	564	5.13	91.7	September	14 750	80.9	369	3.36	86.4
	Rubbish†	.....	....	....	....	.....		872	4.8	3.5	.03	.8
	Garbage	2 400	9.6	51	0.46	8.3		2 600	14.3	55	.50	12.8
	Market refuse	0	0.0	0	0.0	0.0		0	0.0	0	0.00	0.0
	Total	24 950	100.0	615	5.59	100.0		18 222	100.0	427.5	3.89	100.0
April	Ashes (b)	22 750	89.8	569	5.17	91.3	October	15 000	82.3	375	3.41	86.7
	Rubbish	......	....	.....	....	.....		654	3.6	2.5	.02	.6
	Garbage	2 550	10.2	54	0.49	8.7		2 600	14.1	55	.50	12.7
	Market refuse	0	0.0	0	0.0	0.0		0	0.0	0.	0.00	0.0
	Total	25 300	100.0	623	5.67	100.0		18 254	100.0	432.5	3.93	100.0
May	Ashes	21 800	88.6	545	4.96	91.5	November	14 300	82.0	358	3.26	87.4
	Rubbish	523	2.2	2	.02	0.3		872	5.0	3.5	.03	.8
	Garbage	2 300	9.2	49	.45	8.2		2 300	13.0	49	.45	11.8
	Market refuse	0	0.0	0	0.0	0.0		0	0.0	0.	0.00	0.0
	Total	24 623	100.0	596	5.42	100.0		17 472	100.0	410.5	3.74	100.0
June	Ashes	17 950	85.7	449	4.08	89.0	December	20 000	85.0	500.	4.55	89.1
	Rubbish	436	2.1	1.75	.02	0.3		818	3.5	3.25	.03	.6
	Garbage	2 550	12.2	54	.49	10.7		2 700	11.5	58.	.53	10.3
	Market refuse	0	0.0	0	0.0	0.0		0	0.0	0.	0.00	0.0
	Total	20 936	100.0	504.75	4.59	100.0		23 518	100.0	561.25	5.11	100.0
Average	Ashes (b)							18 617	85.1	465.00	4.23	89.1
	Rubbish							740†	3.4	3.00	.03	0.6
	Garbage							2 525	11.5	54.00	.49	10.3
	Market refuse							0	0.0	0.00	.00	0.0
	Total							21 882	100.0	522.00	4.75	100.0

* 5½ days per week. (b) During January, February, March and April, rubbish and ashes both reported under the head of Ashes. † Average for eight months only.
1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 6.—BOSTON REFUSE DISPOSAL. SHOWING AVERAGE WEEKLY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM **Brighton** (DISTRICT NO. 4) DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (Population, 1905. 22 000).

		Cubic Feet.		Tons.				Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	16 500	87.8	413	6.89	89.4	July	13 000	86.3	325	5.42	88.6
	Rubbish	......	....	....	...	.....		......	.....	...	....	.....
	Garbage	2 300	12.2	49	.82	10.6		1 950	13.7	42	.70	11.4
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
–	Total	18 800	100.0	462	7.71	100.0		14 950	100.0	367	6.12	100.0
February	Ashes	16 450	88.0	411	6.85	89.5	August	13 100	86.9	328	5.47	88.7
	Rubbish	......	.....	...	....	.....		......	.....	...	....	.....
	Garbage	2 250	12.0	48	.80	10.5		1 950	13.1	42	.70	11.3
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	18 700	100.0	459	7.65	100.0		15 050	100.0	370	6.17	100.0
March	Ashes	16 200	88.0	405	6.76	89.4	September	12 800	86.8	320	5.33	88.3
	Rubbish	......	.....	...	....	.....		......	.....	...	....	.....
	Garbage	2 250	12.0	48	.80	10.6		1 950	13.2	42	.70	11.7
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	18 450	100.0	453	7.56	100.0		14 750	100.0	362	6.03	100.0
April	Ashes	15 750	87.2	394	6.57	89.1	October	13 600	87.0	340	5.67	88.5
	Rubbish	......	....	...	....	....		......	....	...	....	....
	Garbage	2 250	12.8	48	.80	10.9		2 050	13.0	44	.73	11.5
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	18.000	100.0	442	7.37	100.0		15 650	100.0	384	6.40	100.0
May	Ashes	15 000	88.0	375	6.25	89.5	November	13 400	86.9	335	5.58	88.5
	Rubbish	......	....	...	....	....		......	....	...	....	....
	Garbage	2 050	12.0	44	.73	10.5		2 050	13.1	44	.73	11.5
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	17 050	100.0	419	6.98	100.0		15 450	100.0	379	6.31	100.0
June	Ashes	13 000	86.3	325	5.42	88.1	December	15 500	88.0	388	6.47	89.5
	Rubbish	......	....	...	....	....		......	....	...	....	....
	Garbage	2 050	13.7	44	.73	11.9		2 100	12.0	45	.75	10.5
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	15 050	100.0	369	6.15	100.0		17 600	100.0	433	7.22	100.0
Average	Ashes							14 525	87.3	363	6.06	88.9
	Rubbish							......	....	...	....	....
	Garbage							2 100	12.7	45	.75	11.1
	Market refuse							0	0.0	0	0.00	0.0
	Total							16 625	100.0	408	6.81	100.0

* 5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 7.—BOSTON REFUSE DISPOSAL. SHOWING AVERAGE WEEKLY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM **West Roxbury** (DISTRICT No. 5) DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (Population, 1905, 37 000.)

		Cubic Feet.		Tons.				Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	27 350	86.7	684	7.46	88.6	July	13 400	80.2	335	3.65	82.6
	Rubbish	......	....	...	....	....		......	....	...	....	....
	Garbage	4 150	13.3	88	.96	11.4		3 350	19.8	71	.77	17.4
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	31 500	100.0	772	8.42	100.0		16 750	100.0	406	4.42	100.0
February	Ashes	29 450	88.0	736	8.02	89.6	August	14 200	78.0	355	3.87	80.7
	Rubbish	......	....	...	...	....		......	.....	...	...	.....
	Garbage	4 000	12.0	85	.93	10.4		4 000	22.0	85	.93	19.3
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	33 450	100.0	821	8.95	100.0		18 200	100.0	440	4.80	100.0
March	Ashes	28 750	87.0	719	7.83	88.9	September	14 900	77.8	373	4.06	80.5
	Rubbish	......	....	...	....	....		......	....	...	...	....
	Garbage	4 250	13.0	90	.98	11.1		4 250	22.2	91	.99	19.5
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	33 000	100.0	809	8.81	100.0		19 150	100.0	464	5.05	100.0
April	Ashes	29 100	89.1	727	7.92	90.5	October	19 250	82.8	481	5.25	85.0
	Rubbish	......	....	....	....	....		......	....	...	...	...
	Garbage	3 550	10.9	76	.83	9.5		4 000	17.2	85	.93	15.0
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	32 650	100.0	803	8.75	100.0		23 250	100.0	566	6.18	100.0
May	Ashes	26 250	87.8	656	7.15	89.3	November	20 600	84.5	515	5.61	86.4
	Rubbish	......	....	...	....	....		......	....	...	....	....
	Garbage	3 700	12.2	79	.86	10.7		3 800	15.5	81	.88	13.6
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	29 950	100.0	735	8.01	100.0		24 400	100.0	596	6.49	100.0
June	Ashes	15 600	81.5	390	4.25	83.6	December	24 550	85.7	614	6.70	87.6
	Rubbish	......	....	...	....	....		......	....	...	....	....
	Garbage	3 550	18.5	76	.83	16.4		4 100	14.3	87	.95	12.4
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	19 150	100.0	466	5.08	100.0		28 650	100.0	701	7.65	100.0
Average	Ashes							21 950	84.1	549	5.98	86.1
	Rubbish							......	....	...	....	....
	Garbage							3 892	15.9	83	.90	13.9
	Market refuse							0	0.0	0	0.00	0.0
	Total							25 842	100.0	632	6.88	100.0

* 5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 8.—BOSTON REFUSE DISPOSAL. SHOWING AVERAGE WEEKLY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM **Dorchester** (DISTRICT No. 6) DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (Population, 1905, 89 000.)

		Cubic Feet.		Tons.					Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.			Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	56 350	87.6	1 409	6.08	89.3	July		19 200	75.1	480	2.07	78.0
	Rubbish	......	....	.....	....	....			......	....	....	....	....
	Garbage	7 950	12.4	169	.73	10.7			6 350	24.9	135	.58	22.0
	Market refuse	0	0.0	0	0.00	0.0			0	0.0	0	0.00	0.0
	Total	64 300	100.0	1 578	6.81	100.0			25 550	100.0	615	2.65	100.0
February	Ashes	66 100	89.0	1 653	7.14	90.4	August		18 650	71.3	466	2.02	74.4
	Rubbish	......	....	.....	....	....			......	.....	....	....	....
	Garbage	8 200	11.0	175	.76	9.6			7 500	28.7	160	.69	25.6
	Market refuse	0	0.0	0	0.00	0.0			0	0.0	0	0.00	0.0
	Total	74 300	100.0	1 828	7.90	100.0			26 150	100.0	626	2.71	100.0
March	Ashes	60 300	88.9	1 508	6.50	90.4	September		22 850	77.2	571	2.47	79.9
	Rubbish	......	....	.....	....	....			......	....	.....	....	....
	Garbage	7 500	11.1	160	.69	9.6			6 750	22.8	144	.62	20.1
	Market refuse	0	0.0	0	0.00	0.0			0	0.0	0	0.00	0.0
	Total	67 800	100.0	1 668	7.19	100.0			29 600	100.0	715	3.09	100.0
April	Ashes	49 650	88.4	1 241	5.36	90.0	October		28 500	79.8	713	3.08	82.3
	Rubbish	......	....	.....	....	....			......	....	...	....	....
	Garbage	6 500	11.6	138	.59	10.0			7 200	20.2	153	.66	17.7
	Market refuse	0	0.0	0	0.00	0.0			0	0.0	0	0.00	0.0
	Total	56 150	100.0	1 379	5.95	100.0			35 700	100.0	866	3.74	100.0
May	Ashes	34 150	85.1	854	3.68	87.0	November		39 950	85.5	999	4.31	87.3
	Rubbish	......	....	...	....	....			......	....	...	....	....
	Garbage	6 000	14.9	128	.55	13.0			6 800	14.5	145	.63	12.7
	Market refuse	0	0.0	0	0.00	0.0			0	0.0	0	0.00	0.0
	Total	40 150	100.0	982	4.23	100.0			46 750	100.0	1 144	4.04	100.0
June	Ashes	22 400	76.8	560	2.42	79.5	December		51 800	87.1	1 295	5.58	88.8
	Rubbish	......	....	...	....	....			......	....	....	....	....
	Garbage	6 750	23.2	144	.62	20.5			7 700	12.9	164	.71	11.2
	Market refuse	0	0.0	0	0.00	0.0			0	0.0	0	0.00	0.0
	Total	29 150	100.0	704	3.04	100.0			59 500	100.0	1 459	6.29	100.0
Average	Ashes								39 158	84.6	979	4.23	86.6
	Rubbish								......	....	...	....	....
	Garbage								7 100	15.4	151	.65	13.4
	Market refuse								0	0.0	0	0.00	0.0
	Total								46 258	100.0	1 130	4.88	100.0

* 5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 9. — BOSTON REFUSE DISPOSAL. Showing Average Weekly Quantities (Cu. Ft. and Tons) of Refuse Collected from **Roxbury** (District No. 7) during Each Month of the Year, May, 1906, to April, 1907. (Population, 1905, 109 000.)

		Cubic Feet.		Tons.				Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	57 800	83.7	1 445	4.74	88.1	July	34 750	77.2	869	2.85	82.8
	Rubbish	2 456	3.6	10	.03	.6		2 234	4.9	9	.03	.9
	Garbage	8 750	12.7	186	.61	11.3		8 050	17.9	171	.56	16.3
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	69 006	100.0	1 641	5.38	100.0		45 034	100.0	1 049	3.44	100.0
February	Ashes	56 100	84.2	1 403	4.62	88.5	August	35 600	75.1	890	2.92	80.9
	Rubbish	2 398	3.6	10	.03	.6		2 398	5.1	10	.03	.9
	Garbage	8 150	12.2	174	.57	10.9		9 400	19.8	200	.66	18.2
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	66 648	100.0	1 587	5.22	100.0		47 398	100.0	1 100	3.61	100.0
March	Ashes	58 400	84.9	1 460	4.80	89.0	September	33 900	75.1	848	2.78	81.2
	Rubbish	2 344	3.4	9	.03	.6		2 507	5.6	10	.03	1.0
	Garbage	8 050	11.7	171	.56	10.4		8 750	19.3	186	.61	17.8
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	68 794	100.0	1 640	5.39	100.0		45 157	100.0	1 044	3.42	100.0
April	Ashes	58 950	85.4	1 474	4.85	89.6	October	39 250	77.1	981	3.22	82.8
	Rubbish	2 398	3.5	10	.03	.6		2 507	4.9	10	.03	.8
	Garbage	7 600	11.1	162	.51	9.8		9 150	18.0	195	.64	16.4
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	68 948	100.0	1 646	5.39	100.0		50 907	100.0	1 186	3.89	100.0
May	Ashes	59 150	85.2	1 479	4.85	89.3	November	41 500	80.3	1 038	3.40	85.4
	Rubbish	2 398	3.5	10	.03	.6		2 224	4.3	9	.03	.7
	Garbage	7 850	11.3	167	.55	10.1		7 950	15.4	169	.55	13.9
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	69 398	100.0	1 656	5.43	100.0		51 674	100.0	1 216	3.98	100.0
June	Ashes	40 200	78.9	1 005	3.30	84.6	December	51 850	83.3	1 296	4.25	87.7
	Rubbish	2 616	5.1	10	.03	.8		2 289	3.7	9	.03	.6
	Garbage	8 150	16.0	174	.57	14.6		8 100	13.0	173	.57	11.7
	Market refuse	0	0.0	0	0.00	0.0		0	0.0	0	0.00	0.0
	Total	50 966	100.0	1 189	3.90	100.0		62 239	100.0	1 478	4.85	100.0
Average	Ashes							47 288	80.8	1 182	3.88	85.8
	Rubbish							2 398	4.3	10	.03	.7
	Garbage							8 329	14.9	177	.58	13.5
	Market refuse							0	0.0	0	0.00	0.0
	Total							58 015	100.0	1 369	4.49	100.0

* 5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 10.—BOSTON REFUSE DISPOSAL. SHOWING AVERAGE WEEKLY QUANTITIES (CU. FT. AND TONS) OF REFUSE COLLECTED FROM **South End and Back Bay** (DISTRICTS NOS. 8 AND 9) DURING EACH MONTH OF THE YEAR, MAY, 1906, TO APRIL, 1907. (Population, 1905, 103 000.)

		Cubic Feet.		Tons.					Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.			Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	108 250	66.9	2 706	9.97	82.5	July	Ashes	54 950	56.2	1 374	5.06	75.5
	Rubbish	32 722	20.2	129	.47	3.9		Rubbish	27 010	27.6	106	.39	5.8
	Garbage	20 800	12.9	443	1.63	13.6		Garbage	15 800	16.2	337	1.24	18.7
	Market refuse	0	0.0	0	0.00	0.0		Market refuse	0	0.0	0	0.00	0.0
	Total	161 772	100.0	3 278	12.07	100.0		Total	97 760	100.0	1 817	6.69	100.0
February	Ashes	109 650	69.1	2 741	10.09	83.7	August	Ashes	58 450	56.3	1 461	5.38	75.6
	Rubbish	29 212	18.4	115	.42	3.5		Rubbish	28 449	27.4	112	.41	5.8
	Garbage	19 800	12.5	422	1.55	12.8		Garbage	16 900	16.3	360	1.33	18.6
	Market refuse	0	0.0	0	0.00	0.0		Market refuse	0	0.0	0	0.00	0.0
	Total	158 662	100.0	3 278	12.06	100.0		Total	103 799	100.0	1 933	7.12	100.0
March	Ashes	109 700	68.3	2 743	10.09	83.5	September	Ashes	56 150	55.7	1 404	5.17	74.7
	Rubbish	31 196	19.4	122	.45	3.7		Rubbish	27 272	27.1	107	.40	5.7
	Garbage	19 650	12.3	418	1.54	12.8		Garbage	17 300	17.2	368	1.35	19.6
	Market refuse	0	0.0	0	0.00	0.0		Market refuse	0	0.0	0	0.00	0.0
	Total	160 546	100.0	3 283	12.08	100.0		Total	100 722	100.0	1 879	6.92	100.0
April	Ashes	102 350	66.8	2 559	9.42	82.5	October	Ashes	67 250	56.5	1 681	6.19	75.3
	Rubbish	31 610	20.6	124	.46	4.0		Rubbish	31 501	26.4	124	.46	5.4
	Garbage	19 350	12.6	412	1.52	13.5		Garbage	20 400	17.1	434	1.60	19.3
	Market refuse	0	0.0	0	0.00	0.0		Market refuse	0	0.0	0	0.00	0.0
	Total	153 310	100.0	3 095	11.40	100.0		Total	119 151	100.0	2 239	8.25	100.0
May	Ashes	80 550	62.7	2 014	7.41	79.5	November	Ashes	80 400	62.6	2 010	7.40	79.3
	Rubbish	28 558	22.3	112	.41	4.4		Rubbish	28 536	22.2	112	.41	4.4
	Garbage	19 200	15.0	409	1.51	16.1		Garbage	19 550	15.2	416	1.53	16.3
	Market refuse	0	0.0	0	0.00	0.0		Market refuse	0	0.0	0	0.00	0.0
	Total	128 308	100.0	2 535	9.33	100.0		Total	128 486	100.0	2 538	9.34	100.0
June	Ashes	64 100	56.9	1 603	5.90	76.0	December	Ashes	101 800	66.0	2 545	9.37	81.5
	Rubbish	30 356	26.9	119	.44	5.6		Rubbish	31 087	20.2	122	.45	3.9
	Garbage	18 300	16.2	390	1.44	18.4		Garbage	21 300	13.8	454	1.67	14.6
	Market refuse	0	0.0	0	0.00	0.0		Market refuse	0	0.0	0	0.00	0.0
	Total	112 756	100.0	2 112	7.78	100.0		Total	154 187	100.0	3 121	11.49	100.0
Average	Ashes								82 800	63.0	2 070	7.62	79.8
	Rubbish								29 792	22.6	117	.43	4.5
	Garbage								19 030	14.4	405	1.50	15.7
	Market refuse								0	0.0	0	0.00	0.0
	Total								131 622	100.0	2 592	9.55	100.0

*5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

TABLE No. 11. — BOSTON REFUSE DISPOSAL. Showing Average Weekly Quantities (Cu. Ft. and Tons) of Refuse Collected from **North and West Ends** (District No. 10) during Each Month of the Year, May, 1906, to April, 1907. (Population, 1905, 73 000.)

		Cubic Feet.		Tons.				Cubic Feet.		Tons.		
		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.		Average Weekly.	Per Cent.	Average Weekly.	Lb.* per Capita per Day.	Per Cent.
January	Ashes	87 500	67.1	2 188	9.97	82.8	July	61 100	63.1	1 528	6.97	81.4
	Rubbish	26 531	20.3	104	.48	4.0		23 740	24.5	93	.42	4.9
	Garbage	10 400	8.0	221	1.01	8.4		9 550	9.9	202	.93	10.9
	Market refuse	6 030	4.6	128	.58	4.8		2 410	2.5	52	.24	2.8
	Total	130 461	100.0	2 641	12.04	100.0		96 800	100.0	1 875	8.56	100.0
February	Ashes	91 350	68.0	2 284	10.42	83.5	August	66 600	61.5	1 666	7.58	78.4
	Rubbish	26 574	19.8	104	.48	3.8		24 656	22.9	97	.44	4.6
	Garbage	10 050	7.5	214	.97	7.8		10 000	9.2	213	.97	10.0
	Market refuse	6 360	4.7	136	.61	4.9		6 980	6 4	149	.68	7.0
	Total	134 334	100.0	2 738	12.48	100.0		108 236	100.0	2 125	9.67	100.0
March	Ashes	86 650	65.8	2 166	9.89	81.9	September	65 400	60.2	1 635	7.46	77.3
	Rubbish	27 304	20.8	108	.49	4.1		25 310	23.3	100	.46	4.8
	Garbage	10 550	8.0	225	1.02	8.4		9 950	9.2	212	.96	10.0
	Market refuse	7 050	5.4	150	.68	5.6		7 920	7.3	169	.76	7.9
	Total	131 554	100.0	2 649	12.08	100.0		108 580	100.0	2 116	9.64	100.0
April	Ashes	85 300	66.0	2 132	9.72	82.4	October	71 300	62.1	1 783	8.14	79.5
	Rubbish	27 850	21.5	110	.50	4.2		26 596	23.2	104	.48	4.7
	Garbage	9 750	7.5	208	.95	8.1		10 150	8.8	216	.97	9.5
	Market refuse	6 430	5.0	137	.62	5.3		6 780	5.9	144	.65	6.3
	Total	129 330	100.0	2 587	11.79	100.0		114 826	100.0	2 247	10.24	100.0
May	Ashes	71 100	61.9	1 777	8.11	78.9	November	74 200	63.0	1 855	8.46	80.5
	Rubbish	26 509	23.1	104	.48	4.7		27 642	23.5	109	.50	4.8
	Garbage	10 050	8.7	214	.98	9.5		9 750	8.3	208	.95	9.0
	Market refuse	7 250	6.3	154	.71	6.9		6 160	5.2	132	.60	5.7
	Total	114 909	100.0	2 249	10.28	100.0		117 752	100.0	2 304	10.51	100.0
June	Ashes	66 500	61.0	1 663	7.60	78.2	December	81 800	66.0	2 045	9.32	82.3
	Rubbish	25 288	23.2	100	.45	4.6		26 356	21.3	104	.47	4.1
	Garbage	10 050	9.2	214	.97	10.0		9 850	7.9	210	.96	8.5
	Market refuse	7 180	6.6	153	.70	7.2		5 960	4.8	127	.58	5.1
	Total	109 018	100.0	2 130	9.72	100.0		123 966	100.0	2 486	11.33	100.0
Average	Ashes							75 600	63.8	1 894	8.63	80.7
	Rubbish							26 200	22.2	103	.47	4.4
	Garbage							10 000	8.5	213	.97	9.1
	Market refuse							6 370	5.5	136	.62	5.8
	Total							118 170	100.0	2 346	10.69	100.0

* 5½ days per week. 1 cu. yd. ashes = 1 350 lb. 1 cu. yd. garbage = 1 150 lb. 1 cu. yd. rubbish = 212 lb. 1 cu. yd. market refuse = 1 150 lb.

The foregoing tables indicate that the quantity of ashes and house dirt per capita collected daily throughout the city was greatest in the North and West Ends and in the South End and Back Bay, the districts which include the business portions of the city and the larger hotels. Next to these districts, the quantity was greatest in the suburban residential districts of Brighton and West Roxbury. Practically all of the combustible waste and rubbish is collected in the downtown districts.

The quantity of garbage is greatest per person in the South End and Back Bay (Districts 8 and 9) and next largest in the North and West Ends (District 10), the districts of the great hotels. It will be noted that the quantity of garbage collected in East Boston is much greater per capita than that collected in South Boston or Charlestown. The explanation offered is that East Boston, being a very large shipping point, contains a large floating population in proportion to the population of the district, including sailors and employees of vessels, not recorded in the census.

In the following table is given the average daily quantity of street and catch-basin cleanings collected in the various districts for the year 1906 in loads, cubic feet and tons; also in pounds per capita.

Comparison of Quantities of Waste and Refuse Collected in the Cities of Boston and New York.

Before leaving the question of the quantity of wastes it will be of interest to compare the quantity of wastes collected per capita in the city of Boston with those collected in the boroughs of Manhattan and the Bronx, kindly furnished by Mr. Macdonough Craven, recently street commissioner of the city of New York. These figures are for ashes, rubbish and garbage. They show a very remarkable similarity in the total quantity of such wastes collected in the two cities.

Methods of Disposal of Municipal Waste and Refuse in the City of Boston.

Ashes and House Dirt. — Of the total amount of 466 000 tons of this material collected in the entire city in the year 1906, 132 000 tons, or 28 per cent., were delivered at Fort Hill Wharf on Atlantic Avenue, discharged into scows and dumped at sea, off the mouth of the harbor. All of the remainder of this waste and refuse is disposed of by dumping it upon low grounds in various parts of the city.

TABLE No. 12. — BOSTON REFUSE DISPOSAL.

TABLE SHOWING AVERAGE DAILY* QUANTITIES OF STREET CLEANINGS AND CATCH-BASIN CLEANINGS COLLECTED IN THE CITY OF BOSTON DURING 1906.

Sanitary District.		South Boston.	East Boston.	Charles-town.	Brighton.	West Roxbury.	Dor-chester.	Roxbury.	South End and Back Bay.	North and West Ends.	Entire City.
District Number.		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8 and 9)	(10)	
Population (1905).		75 053	51 334	39 983	21 806	33 352	84 417	110 850	98 822	79 763	595 380
Street Cleanings.	Loads,	60	24.2	33.4	25.7	17.5	30.0	33.4	119.2	65.1	408.5
	Cu. Ft.,	3 000	1 213	1 672	1 288	875	1 500	1 673	5 975	3 255	20 451
	Tons,	55.5	22.5	30.9	23.8	16.2	27.8	31.0	110.5	60.2	378.3
	Lb., †	1.48	.88	1.55	2.18	.97	.65	.56	2.24	1.51	1.27
Catch-Basin Cleanings.	Loads,	8.9	8.2	4.9	5.0	6.0	25.1	27.1	12.3		97.5
	Cu. Ft.,	266	245.5	146.3	151.0	181.0	756.0	814.0	371.0		2 930.8
	Tons,	6.65	6.12	3.65	3.78	4.52	18.90	20.35	9.28		73.27
	Lb., †	.177	.239	.18	.346	.271	.448	.368	1.88		.246
Total.	Loads,	68.9	32.4	38.3	30.7	23.5	55.1	60.5	196.6		506.0
	Cu. Ft.,	3 266	1 458.5	1 818.3	1 439.0	1 056.0	2 250.0	2 487.0	9 601.0		23 381.8
	Tons,	62.15	28.62	34.55	27.58	20.72	46.70	51.35	179.98		451.57
	Lb., †	1 657	1.119	1.73	2.526	1.241	1.098	0.928	5.63		1.516

* $5\frac{1}{2}$ days per week. † Lb. per capita per day. NOTE. — 1 cu. yd. street cleanings = 1 000 lb. 1 cu. yd. catch-basin cleanings = 1 350 lb.

TABLE No. 13. — BOSTON REFUSE DISPOSAL. COLLECTION OF REFUSE IN THE CITIES OF BOSTON* AND NEW YORK† (1906).

	Tons (2 000 Lb.). Total for Year.		Tons (2 000 Lb.). Average per Day. §		Per Cent of Total by Weight.		Lb. per Capita per Day. §	
	Boston.	New York.	Boston.	New York.	Boston.	New York.	Boston.	New York.
Ashes	466 100	1 903 500	1 628	6 654	87.29	82.04	5.470	5.582
Rubbish	12 198	192 496	42	673	2.28	8.30	.143	.565
Garbage	55 700	224 250	195	784	10.43	9.66	.653	.658
Total	533 998	2 320 246	1 865	8 111	100.00	100.00	6.266	6.805

* Population (1905), 595 380.

† BOROUGHS OF MANHATTAN AND THE BRONX.

Population (1905).	
Manhattan	2 112 380
Bronx	271 630
Total	2 384 010

§ $5\frac{1}{2}$ days per week.

NOTE. — 1 cu. yd. ashes = 1 350 lb.
1 " rubbish = 212 "
1 " garbage = 1 150 "

Combustible Waste and Refuse. — Of the total quantity of waste and refuse, so called, collected in the city, amounting to 3 108 000 cu. ft. in the year 1906, 2 829 000 were delivered to an incinerator plant on Hecht Wharf and the remainder deposited on dumps in various parts of the city, where a part of it was burned.

Garbage. — Of the 55 700 tons of house offal collected in the entire city in 1906, 41 960 were conveyed to scows at the Fort Hill and Albany Street wharves — 17 660 tons to the former and 24 300 tons to the latter — and towed to the garbage reduction plant at Spectacle Island. The remainder — 13 740 tons — collected in East Boston, Brighton, West Roxbury and Dorchester, was sold for the feeding of swine.

During the past year the sale of offal from Dorchester for the feeding of swine has been discontinued, and this offal is now delivered at Fort Hill Wharf. Difficulty has been experienced on account of the disposal of offal from East Boston for the purpose of feeding swine, and it is likely that that method of disposal will soon be discontinued and the offal from that district delivered to the reduction plant at Spectacle Island.

The works for the disposal of garbage in the city of Boston were *originally* constructed on the mainland, and, though located more than a mile from any dwellings, yet nuisance was severe, and the plant was subsequently removed to Spectacle Island. References to serious nuisance from this plant in its present location have been made in the newspapers during the past summer.

Street Cleanings. — Of the 5 850 000 cu. ft. of street cleanings collected in the entire city, 1 965 000, or 34 per cent., are delivered to Fort Hill Wharf and dumped at sea. The remainder is dumped with the ashes and other refuse for the filling of low lands.

Catch-Basin Cleanings. — Cesspool and catch-basin cleanings amounted in 1906 to 837 000 cu. ft., of which 190 000, or 23 per cent., were shipped at Fort Hill Wharf and dumped at sea, while the remainder was dumped with the other refuse in the low grounds about the city.

Market Refuse. — The market refuse, amounting to about 8 600 tons, was dumped into scows at Fort Hill Wharf and disposed of at sea. A considerable quantity of market refuse is, however, disposed of on the land dumps in various parts of the city.

Dumping on Land.

The great bulk of the refuse material disposed of from the

city is dumped upon the low grounds, and at the present time the number of such dumping places in use in the city of Boston is in the neighborhood of 60.

The total number of loads of waste and refuse dumped at these places was counted during certain weeks in the month of June, 1907, the results showing that at the largest of these dumps 477 loads of material were disposed of in a single week. At the next largest dump 282 and 283 loads respectively were disposed of in different weeks. At ten other dumps more than 200 loads per week were disposed of, and at eight others between 100 and 200 loads per week were disposed of.

These dumps are used in many places as a playground by children and are a source of constant annoyance to the health department from foul odors and especially from smoke caused by frequent fires. They are usually very unsightly and at times of high winds many acres of ground are sometimes covered by flying debris, chiefly paper, from a large dump.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by August 1, 1908, for publication in a subsequent number of the JOURNAL.]

SEWERAGE STATISTICS.

Collected and Tabulated by the Sanitary Section of the Boston Society of Civil Engineers.

[Presented to the Sanitary Section of the Boston Society of Civil Engineers, May 6, 1908, by a committee consisting of Harrison P. Eddy, Bertram Brewer and Charles Saville.]

The need of better methods of keeping records relative to the operation of both sewerage systems and sewage disposal works is acknowledged by all. At the present time it is almost impossible to obtain from the annual reports of sewer departments statistics which are of any value in comparing the work of such departments in different cities, and it is with the idea of improving these conditions that the Sanitary Section of the Boston Society of Civil Engineers has taken up the matter of collecting available data along these lines and encouraging the adoption of a better and more uniform system of keeping records.

A set of questions in pamphlet form was first prepared including all items of general interest pertaining to the construction and operation of sewerage systems and sewage disposal plants. The pamphlets were sent to a number of cities with the request that the blanks be filled in and the pamphlets returned to the Society. As a result, some twenty-five municipalities located in Massachusetts and neighboring states have contributed a large amount of interesting data.

In some cases, without doubt, this has meant a good deal of work, and the committee wishes to take this opportunity of expressing its appreciation to those who have been kind enough to collect and prepare the desired information. We cannot help feeling, however, that the work has been worth while. In some cases it has been evident that but few accurate records of any kind have been kept, while in other instances the data are probably kept in such shape that they are of little real value. Both of these points have doubtless been brought home to those who have given their time in preparing the pamphlets.

In attempting to collect the data for 1906, only two dozen replies were received, but we hope to hear from at least double this number in 1907, and urge a hearty coöperation on the part of those who are in a position to help in the work.

We would also suggest that the yearly summary of statistics as prepared for this Society be inserted in the annual reports of the sewer departments in the various municipalities. Worcester, Mass., Newton, Mass., and possibly others have already adopted this suggestion.

The information thus far obtained has been summarized in the accompanying tables, which are self-explanatory. The Society hopes to publish similar data for subsequent years, and will welcome suggestions relative to the best method of arranging and tabulating this information.

Statistics for 1906.

In addition to the data presented in the tables considerable information has been obtained relative to the methods employed in the several municipalities for the flushing and cleaning of sewers.

Flushing. — In fifteen instances the pipes are flushed by means of direct connections or special hose connections with the water mains. Flush tanks are used in four places, and reports from two cities state that no regular method of flushing is followed. In one case the desired result is effected by backing up the sewage in the manholes and then allowing it to flush rapidly through the pipes.

Cleaning. — The methods employed for the cleaning of sewers vary to a considerable extent. As it has been found rather difficult to make a summary of this information, it has been given in full.

Arlington, Mass. A special kind of brush is used which is drawn through the sewer from one manhole to another.

Dedham, Mass. Cleaning is effected by flushing and scraping.

Everett, Mass. The Healey sewer cleaning machine is used.

Fall River, Mass. The pipes are cleaned by flushing through connections with city water mains.

Fitchburg, Mass. The material accumulating in the sewers is intercepted at manholes and removed with a shovel and a pail. The Healey sewer cleaner is also used to some extent.

Gardner, Mass. The sewers are cleaned by flushing through connections with town water mains. Small sewers are also cleaned by the use of rods; and the larger ones by the use of steel buckets dragged between manholes.

Table showing Data (for the fiscal year 1906) relative to Sewerage and Sewage Disposal in Certain Cities and Towns in Massachusetts and Neighboring States. Part I.

General

City or Town	Population (Census of 1905)	Total Area of City or Town (Sq. Miles)	Area Served by Sewerage System (Sq. Miles)	Collection System: For Sewage Only (Miles)	Collection System: For Sewage and Surface Water (Miles)	Collection System: For Surface Water Only (Miles)	Method of Disposal
Arlington, Mass.	9 668	5.50	1.70	26.70		6.20	Metropolitan System
Dedham, Mass.	7 774			14.00			Metropolitan System
Everett, Mass.	(g) 29 340	3.32	2.50	(d) 8.50	(d) 1.40	(d) 5.00	Metropolitan System
Fall River, Mass.	(g) 107 011	(e) 39.87			4.00		Tide Water
Fitchburg, Mass.	33 021	28.18	2.03		35.97		Nashua River
Gardner, Mass.	12 012	18.10	2.50	2.50			Settling Tank and Sand Filters
Haverhill, Mass.	37 830	32.00	3.40	3.20	30.30	0.80	Merrimac River
Hopedale, Mass.	2 048	5.54	0.50	4.18		1.5	Septic Tank and Sand Filters
Hyde Park, Mass.	14 510	3.91	2.00	21.00	0.00	3.24	Metropolitan System
Laconia, N. H.	(h) 9 000	10.00	2.00	20.00	0.00	7.00	Lake Winnisquam
Lawrence, Mass.	70 050	6.75	2.95		63.00	0.75	Merrimac River
Lowell, Mass.	94 889	14.20	10.00	1.00	97.33	1.60	Merrimac River
Marlborough, Mass.	14 072	21.00	1.25	24.9		5.5	Sand Filters
Nashua, N. H.	23 898	33.50	4.00		44.50	0.50	Merrimac River
New Bedford, Mass.	(a) 79 076	19.33	6.00	0.43	71.12	0.65	Tide Water (40 outlets)
New London, Conn.	(g) 22 000	6.50	2.00	28.00			Tide Water
Newton, Mass.	36 827	18.00	6.68	161.88		53.69	Metropolitan System
Pawtucket, R. I.	43 381	8.94	2.15		51.86		Part by Sand Filters Part by Dilution
Plainfield, N. J.	18 479	5.90	3.33	36.14		5.20	Septic Tanks and Contact Beds
Springfield, Mass.	(g) 75 000	38.00	7.00	0.18	106.16	0.13	Connecticut River
Waltham, Mass.	26 239	13.56	2.70	41.28	0.0	12.65	Metropolitan System
Watertown, Mass.	11 262	4.17	2.00	32.30	0.0	8.11	Metropolitan System
Westfield, Mass.	13 600	42.00	2.70	20.83		11.10	Westfield River
Worcester, Mass.	128 135	31.42	7.20	73.99	63.00	42.82	Chemical Precipitation and Sand Filters

Collection

City or Town	See Footnote*	Linear Feet Stone	Linear Feet Brick	Linear Feet Concrete	Linear Feet Pipe	Linear Feet Extended during Year	Number of Inverted Siphons	Number of Manholes	Number of Automatic Flush Tanks	Number of Direct Connections with Water Main for Flushing	Number of Flushings of Entire System during Year	Cost of Flushing per Mile	Cost of Cleaning per Mile	Number of Stoppages	Miles of Permanent Under-Drains	Number of Storm Overflows	Method of Ventilation
Arlington, Mass.	A B C				141 185 32 740	258	2	556		40	6	$0.75	$4.00		3	6	Manhole covers
Dedham, Mass.	A		3 400		72 345	1 000			1		1					2	Through plumbing system
Everett, Mass.	A B C		4 400 11 840 400	9 301	103 750 72 500 39 000	1 750 120 6 400	2	630 310 220		3	2 2	12.83	5.00 33.40	6		1	Manholes
Fall River, Mass.	A B C	4 600	105 207	(f) 2 333	241 658	7 620		2 964								6	Perforated manhole covers
Fitchburg, Mass.	B		23 261		166 666	1 484		850									Perforated manhole covers
Gardner, Mass.	A B C				118 261	8 190	4	482						2	3		
Haverhill, Mass.	A B C		41 300	2 200 2 300	17 000 163 500 1 900	2 175 2 067		65 580 18								1	Manholes and catch-basins
Hopedale, Mass.	A				22 900			81									
Hyde Park, Mass.	A B C	1 760		1 250	110 880 13 300	3 180 860		414	6		2			2	12		Covers, house-stacks and catch-basin openings
Laconia, N. H.	A B C	2 640			105 600 36 960	1 000 1 500	3	392 50	86	86	2	6.50		19	1		Stacks through roofs
Lawrence, Mass.	B C		103 600 1 531		228 623	11 582	1	1 176						105		11	Open outlets and perforated manhole covers
Lowell, Mass.	A B C	6 125	167 000		5 260 513 200 8 140	3 000 10 819 176		21 31				1.95	5.00			8	Perforated manhole covers
Marlborough, Mass.	A				134 950	2 200		492		102	12						Manhole covers
Nashua, N. H.	A B C	700	18 315		258 601 1 672	6 700									0.5	6	House connections
New Bedford, Mass.	A B C	1 166	98 286	58	283 250	2 457		624							4	1	Manhole covers and house connections
New London, Conn.	A B C		671	700	147 100	13 000		671		1	4			4	2		Perforated manhole covers
Newton, Mass.	A B C	14 214	56 148 31 430	2 035 15 743	479 620 220 607	6 867 11 740	4 1	2 616 668		100	13	9.80	27.50		85.01	3	Perforated manhole covers and house connections
Pawtucket, R. I.	B		41 257	1 031	201 624	3 854		1 200	124	163	3	0.45	0.37	57	1.7	16	Perforated manhole covers
Plainfield, N. J.	A B C		1 250	3 605	120 840 22 495	14 072 950	1	291 37	107	9		30.33		2	2.42		House connections
Springfield, Mass.	A B C	2 519	143 727	1 104	970 413 070 700	970 6 917				1 367	26	30.28	16.08			15	Manhole covers
Waltham, Mass.	A B C	2 408	9 675 6 901	1 753	308 388 63 201	9 711 400	2	855		115	2	8.46	1.90	8	0.57		Perforated manhole covers and house connections
Watertown, Mass.	A B C		4 013	1 709	171 019 37 300	5 671 2 383	1 1	570 86		50	2	5.30		2		2	Direct through house-stacks
Westfield, Mass.	A B C		21 265.5		141 673 37 100	2 931 4 319	1	517 128					63.30	65			Through manholes
Worcester, Mass.	A B C	556 17 100	71 011 99 472 57 130	2 420 3 432	318 384 230 736 147 840	5 486 3 944 5 856	7 6	6 647	7 2	25 61	4 3	12.16	18.45	1	1.15	34	Only by perforated covers on manholes

House Connections, Catch-Basins, Discharge of Sewage

City or Town	By Whom Made	Sizes (Inches in Diam.)	Number Made during Year	Linear Feet Laid during Year	Linear Feet Discontinued during Year	Total Miles in Use	Average Cost per Foot Connections Made during Year	Number of Stoppages Coming to Attention of Dept.	Number of Catch-Basins	Number Catch-Basins Cleaned	Av. Amt. Material Removed per Catch-Basin (cu. yds.)	Cost of Removing Material per Cubic Yard	Cost of Removing Material per Catch-Basin per Year	Estimated Population Using System	Number of Buildings Connected	Average Number Gallons: Daily Discharge for Year	Average Number Gallons: Daily Discharge for Each User	Average Number Gallons: Daily Quantity Factory Waste	Average Number Gallons: Daily Leakage into Sewers	Average Number Gallons: Daily Leakage per Mile of Sewer
Arlington, Mass.	Town	5	61	3 011		11.25	$0.55	3	184		1	$0.50	$2.00	6 000	1 620					
Dedham, Mass.	Contractor	5	52					2												
Everett, Mass.	Licensed drain-layers	6	106	4 420		31.00	0.60	6	700	440	9	0.52	5.00	28 640	4 500	(k) 5 300 000	(k) 185			
Fall River, Mass.	Licensed drain-layers	6	145	3 625				49	868	2 254	2.76	1.46	4.04							
Fitchburg, Mass.	City	5	47	1 900			0.40		700		3.03	0.77	2.06	24 000	2 900	(k) 2 800 000	(k) 116			
Gardner, Mass.	City	5	93	4 648		8.50	1.23	3						7 500	917					
Haverhill, Mass.	Licensed drain-layers	5	88																	
Hopedale, Mass.	Draper Co.	6												2 250±	(o) 213	(l) 144 000				
Hyde Park, Mass.	Contractor	5	123	6 023	40	9.50	0.60	4	92	80	2	0.75	1.50	7 620	1 675		(k) 50		(k) 400 000	20 000± (k)
Laconia, N. H.	Licensed drain-layers	4	63	2 500				5	600	450	0.5			8 000	972					
Lawrence, Mass.	By plumbers and others	6	176				0.50	75	1 100	2 840	2	0.93	6.04	67 896						
Lowell, Mass.	Private contractors	5 to 8	211	10 500				50	3 364	3 364	1.50	1.10	1.50							
Marlborough, Mass.	City	5	36	1 500		1.40	0.42	10	655	1 310	0.25		1.46	10 700	1 605	(l) 580 000 Av. (l) 1 130 000 Max. (l) 280 000 Min.	(l) 54.4 Av. (l) 130.2 Max. (l) 27.7 Min.			
Nashua, N. H.	Licensed drain-layers	4 to 8	39						1 300	2 400	1			20 000						
New Bedford, Mass.	City	5 to 10	322	12 046			0.48	175	945	All	4	0.50	3.00	70 000		(k) 7 000 000	(k) 95			
New London, Conn.	Plumbers	6	200											15 000	2 219					
Newton, Mass.	City and contractor	5 to 8	107	8 599	300	67.50	0.65	75	2 294	6 832	5.2			28 400	5 150	(k) 3 000 000 Av. (k) 6 000 000 Max. (k) 1 065 000 Min.	(k) 106 Av. (k) 212 Max. (k) 38 Min.			
Pawtucket, R. I.	By property owners	6	172	4 300		17.43	0.60		1 028	1 162	1.7	(l) 1.04	(l) 1.77	33 183	4 484					
Plainfield, N. J.	Licensed plumbers	1	261				0.72	3	53	53	7			13 250	2 613	(l) 1 100 000 Av. (l) 1 400 000 Max. (l) 900 000 Min.	(l) 75		(k) 400 000 Max.	
Springfield, Mass.	City	6 to 8	209	6 725			0.48													
Waltham, Mass.	City	4 and 5	82	5 685	147	40.22	0.42	70	300	All. Some 3 times			3.00	24 500	3 118					
Watertown, Mass.	Town	4 and 5	36	1 906			0.92	43												
Westfield, Mass.	Plumbers	4, 5 and 6	50					12	317	317			0.35	12 480	1 819	(l) 2 525 000	By one meas'ment			
Worcester, Mass.	Licensed drain-layers	6	320	21 770	316	118.50	0.50	17	2 518	1 622	6.73	0.50	3.32	120 200		Millions (m) 14.67 Av. (m) 20.653 Max. (m) 8.019 Min.	(m) 122.0 Av. 171.8 Max. 62.7 Min.		(m) 3 127 000	(m) 23 130

* A, For sewage only. B, For sewage and surface water. C, For surface water only.

(a) Special census.
(e) Land and water.
(d) Acres.

(f) Stone and brick.
(g) 1906.
(h) 1900.

(i) 1904-1906.
(k) Estimated.
(l) Measured.

(m) Measured and estimated.
(o) Including factories.

Table showing Data (for the fiscal year 1906) relative to Sewerage and Sewage Disposal in Certain Cities and Towns in Massachusetts and Neighboring States. Part II.

Pumping

City or Town	Description of Plants	Disc. of Fuels or Power Used: Coal: Kind	Coal: Brand	Coal: Av. Cost per Gross Ton Delivered	Coal: Per Cent. of Ash	Fuel for Int. Combustion Engines: Kind and Grade	Fuel for Int. Combustion Engines: Av. Cost per Gal.	Electricity. Av. Cost per K. W. Hour	Yearly Amount of Fuel or Power Used	Total Gals. Pumped for Year with or without Allowance for Slip	Av. Static Head against which Pump Works, in Feet	Av. Dynamic Head against which Pump Works, in Feet	No. of Gals. raised one Foot per Unit of Fuel or Power	Cost of Pumping ... per Mil. Gals. raised one Ft. ...	Describe Screens
Gardner, Mass. (h)															
Hopedale, Mass.	No. 6 Centrifugal Pump	Power furnished by main power plant of the Draper Company								50 000 000 (e)	22				Wire cloth
Marlborough, Mass.	2 Warren Steam Pumps Cap. 20,000 gals. per hour	Bitu-min.	*	$5.10					11.8 tons	3 285 000	66	68	7 700 per lb. of coal	$0.27	Vertical 1" steel bars 1" on centers
Newton, Mass.	One plant consisting of two 3½" centrifugal pumps operated by two 6 horse-power gasoline engines					Gasoline 72 Test	$0.12½		1 20? gal. gasoline	9 622 434 (b)	28.75	34.85	230 321	1.12	1" mesh woven wire basket
Pawtucket, R. I.															
Plainfield, N. J.															Flat bars 0.5in. spaces
Worcester, Mass.	No. 1. Vert. Cent. Pump connected by bevel gears to electric motor. No. 2. Shone System compressed air, one lift. No. 3. Like 2, three lifts.							$0.06	No. 1. 2 881 k.w. " 2. 5 861 " " 3. 29 107 "	32 900 000 7 224 000 7 161 000 (e)	No. 1. 7.62 " 2. 41.75 " 3. 185.3		No. 1. 66 500 " 2. 52 200 " 3. 54 500	2.14 Static	No. 1 has small basket screen Nos. 2, 3 no screens

Disposal

City or Town	No. of Tanks: Settling	No. of Tanks: Septic	No. of Tanks: Chem. Precipitation	Total Capacity of Tanks up to Flow Line, Gallons	Av. Daily Quantity of Sewage Treated (Gallons)	Av. No. of Hours Sewage is in Tanks	Disposition of Effluent	Disposition of Sludge	Cu. Yds. Sludge produced per Million Gals. Sewage	How Often are Tanks Emptied?	Cost of Tanks	Cost of Maintenance, Including Cost of Disposing of Sludge	Kinds and Quantities of Chemicals used per Million Gallons
Gardner, Mass. (h)	2 Gardner 4 Templeton			10 501 166 850			Treatment on sand filters	Fertilizer at sewer farms		1 in 2 weeks 1 in 2 mos.	$1 150.01 5 983.00	$1 175.92	
Hopedale, Mass.		2		50 500	144 000	12							
Marlborough, Mass.	2			8 100	520 000	0.75	Treatment on sand filters	Sludge beds		Every week			
Newton, Mass.													
Pawtucket, R. I.	2			136 468	243 799	13.4	Treatment on sand filters	Earth cov'd dump	12.06	Twice daily	3 500.00		
Plainfield, N. J.		4		1 320 000	1 100 000	11	Contact beds	Fertilizer	4.44	Once yearly			
Worcester, Mass.		1 (f)	15	5 500 000	11 000 000	4 to 8	Blackstone River	Pressed, dumped	44.6	Roughing 2-4 weeks; others, 4-8 weeks	253 628.75	38 900.10	912 lbs. lime

Sewage Beds or Filters

City or Town	Type	Date of Construction of Works	Cost of Beds	Total Net Filtration Area (Acres)	Number of Beds	Average Area of Beds (Acres)	Were Loam and Subsoil Removed?	Character of Filtering Material Effective Size (mm.)	System of Underdrains: Depth	System of Underdrains: Distance apart	Average Daily Quantity of Sewage Treated (Gallons)	Average Daily Quantity of Sewage Treated per Acre (Net Area)	Maximum Daily Quantity of Sewage Treated (Gallons)	Preliminary Treatment	Dosing Apparatus and Size of Dose (Gallons)	How Long does Sewage flow on One Bed?	How Often is Each Bed used?	Method of Caring for Surface of Filters, Number of Times Raked, Plowed, etc.	Cubic Yards of Material Removed from Surface of Beds	Cost of Removing Same	Are Crops Raised? If so, what kind?	Amount Received for Crops	Total Cost of Maintenance	Cost of Maintenance per Million Gallons Filtered	Water Capacity of Contact or Trickling Filters and Decrease in same since Plant was Started
Gardner, Mass. (h)	Sand filters	1891-2-3 & 6 1901 & 04	$15 751.00 15 697.00	2 3½	31 42	0.125 0.25	Yes		4½ 3½	20 27				Settl. tanks, Coke strainers		6 h. by d. 12 at nt.	Abt. ev'y otherday	Once per year	120 36	$90.00 48.00	No				
Hopedale, Mass.	Sand filters	1890		2.35	4	.587	Yes	Sand and gravel	6'							2 hours	Every 24 hours				No				
Marlborough, Mass.	Sand filters	1890-91	34 517.10 (a)	11	18	0.7	Yes	0.14	5'	50	782 000	62 000	1 190 000	Settling tanks and screens	300 000	8-16 hours	3 or 4 times per m.	Thoroughly cleaned 3 times a year	770	231.00	Corn		$919.95	$1.72	
Newton, Mass.																									
Pawtucket, R. I.	Sand filters	1891		3.26	16	.15 to ¼	Yes	0.17	5	30	157 401	46.80	200 000	Settl. tanks	By hand 10000 gallons		Ev'ry 24 to 72 hrs.	Scraped twice annually and furrowed once	1 170	1 240.30	No				
Plainfield, N. J.	Contact beds	1896 1901 1905	92,000.00 (c)	3.52	16	0.22	Yes	Broken stone, slag, clinker; 1" to 1½"	5" tile collat'g from gate chamber		1 100 000	378 000	1 400 000	Screened and passed through 2 septic tanks successively		2 hours	Twice daily	Raked around distributors monthly		About 180.00	No		1 287.61 +	5.45	125 000 to 150 000 gallons (d)
Worcester, Mass.	Intermittent sand filter	1890-1906	192 960.64	42.5	43	0.99	Yes	Av. 16 b'ds 0.23 mm. Av. 9 b'ds 0.16 mm. Av. 8 b'ds .30 mm.	5	45	2 200 000	63 000	9 200 000	Through grit chamber 40' x 10' x 10'	Controlled by gate valves on main dikes and molasses gates at distributors (g)	2-4 hours	1-4 times weekly	Raked near distributors every 2-4 weeks; rest every 4-8 weeks	19 435	7750.00	No		11 093.81	10.62	

* Georges Creek. (a) Including land. (b) With allowance for slip. (c) Includes septic tanks. (d) Decrease 43% in 4 years. (e) Without allowance for slip. (f) For experimental purposes. (g) Deposit removed 3 or 4 times a year. (h) Two areas, one in Gardner, one in Templeton.

TABLE SHOWING DATA (FOR THE FISCAL YEAR 1906) RELATIVE TO SEWERAGE AND SEWAGE DISPOSAL IN CERTAIN CITIES AND TOWNS IN MASSACHUSETTS AND NEIGHBORING STATES. PART III.

FINANCIAL

Construction

City or Town	Receipts: Balance of Previous Year	Receipts: Bonds Issued	Receipts: Appropriation	Receipts: Assessments	Receipts: House Connections	Receipts: Other Sources	Receipts: Total	Expenditures (Collection Works): Mains	Expenditures (Collection Works): House Connections	Expenditures: Disposal and Purification Works	Expenditures: Balance	Expenditures: Total
Arlington, Mass.			$1 100.00	$337.38	$2 186.55	$620.90	$4 149.84	$402.01	$2 068.80	$678.97	$380.12	$4 149.84
Fitchburg, Mass.		$3 270.00		2 012.60	1 910.21		7 172.93	6 797.49			375.44	7 172.93
Gardner, Mass.	$7 983.44	15 000.00					22 983.44	15 [illegible]			7 385.35	22 983.44
Haverhill, Mass.	967.88	10 000.00				54.00	11 021.88	12 440.70				12 440.70
Hyde Park, Mass.												
Laconia, N. H.	46.47		140.65				187.12	140.65				140.65
Lawrence, Mass.			13 311.61	3 229.20		1 312.78	17 853.59	17 853.59				17 853.59
Marlborough, Mass.	4 140.16				1 026.47	3.07	5 169.70	3 655.00	886.60		628.10	5 169.70
Nashua, N. H.			18 915.15				18 915.15	18 915.15				18 915.15
New Bedford, Mass.					6 500.00			5 780.83	6 500.00			12 280.83
New London, Conn.		68 492.98	73 077.00	224 049.31		88.59	365 707.88	295 273.73			70 434.15	365 707.88
Newton, Mass.	5 109.25	15 000.00	2 862.85	13 360.46	3 269.75		39 562.31	16 288.38	5 850.78		17 423.15	39 562.31
Pawtucket, R. I.	5 282.79		12 325.23	5 143.23		106.75	22 858.10		11 773.54		11 084.56	22 858.10
Plainfield, N. J.								8 776.91	409.64 (to curb)	$2 041.01		
Springfield, Mass.			28 011.00	7 316.82	3 394.37	985.85		16 744.02	3 267.81	◁——	——	Paid from
Waltham, Mass.	18 690.02	27 000.00	175.00		2 732.18	28.73	48 645.93	25 803.12	2 546.37		20 296.44	48 645.93
Watertown, Mass.	8.31		12 000.00		401.53		12 409.53	9 916.27	1 5[illegible].87			
Westfield, Mass.	345.96		17 816.00			65.18	18 227.14	14 177.39			4 049.75	18 227.14
Worcester, Mass.	2 456.73	30 000.00	42 300.00	22 320.98		15 119.02	102 296.63	51 948.88		17 223.34	33 125.31	102 296.63

Maintenance and Operation

City or Town	Receipts: Balance of Previous Year	Receipts: Appropriation	Receipts: Assessments	Receipts: Other Sources	Receipts: Total	Expenditures: Administration	Expenditures: Repairs	Expenditures: Cleaning Sewers	Expenditures: Cleaning Catch-Basins	Expenditures: Flushing Sewers	Expenditures: Pumping	Expenditures: Disposal or Purification[1]	Expenditures: Unclassified Expenses	Expenditures: Balance	Expenditures: Total
Arlington, Mass.								$678.92							
Fitchburg, Mass.		$3 000.00		$2 107.67	$5 107.67		$517.07	$106.25	$3 710.23	$413.08			$271.01		$5 107.67
Gardner, Mass.	$798.65	1 000.00		97.50	1 876.15					187.95 (c)		$1 170.92	61.12	$419.16	1 876.15
Haverhill, Mass.		1 000.00	$3 235.72	203.48	4 439.20								2 862.51		2 862.51
Hyde Park, Mass.															
Laconia, N. H.	647.80	1 000.00	265.00		1 912.80	$500.00				300.00					800.00
Lawrence, Mass.					11 658.39	1 440.19	850.45	603.45	8 800.00					1 112.99	11 658.39
Marlborough, Mass.		2 000.00	8 821.86 (e)		10 821.86						$61.29	1 312.97	626.44	8 821.26	10 821.20
Nashua, N. H.		61.70			61.70		61.70								61.70
New Bedford, Mass.						1 105.76	44.83	199.55	3 887.77						12 358.00
New London, Conn.	5 488.64	14 000.00	23 781.00	193.44		3 992.30									
Newton, Mass.		6 137.15		11 627.30	17 764.45	406.49	4 279.13			1 100.00	177.70	11 384.56	113.74	2.43	17 764.45
Pawtucket, R. I.		11 257.89		350.73	11 758.02	7 128.29	725.07	2 211.18	2 790.00			5 613.59	890.63	3 517.06	17 758.02
Plainfield, N. J.		4 500.00		292.38	4 792.38	1 300.00	120.49			731.87		1 987.01	487.11	223.30	4 792.38
Springfield, Mass.	Street	Dept.	Funds	——	——▷	2 307.63	8 201.84	1 712.30	1 011.85	2 170.04			4 591.71	107.02	20 587.01
Waltham, Mass.		9 453.86			9 450.86	317.32	670.76	75.77		338.79		7 950.96	87.95	27.10	9 450.86
Watertown, Mass.							716.85								
Westfield, Mass.	10.00	1 600.00		141.52	1 730.53			1 427.25	181.52					121.76	1 730.53
Worcester, Mass.	101.66	85 000.00		3 191.50	88 293.16	1 031.35	7 618.60	4 518.91	10 106.29	1 073.46	1 011.00	59 793.10	7 015.48 (i)	143.82	88 293.16

Interest, Sinking Fund and General

City or Town	Interest on Bonds	Sinking Fund	Total Cost Collecting Mains	Total Cost Pumping System	Total Cost Disposal Works	Total Cost Works to Date	Bonded Debt at Date	Value Sinking Fund at Date	Average Rate of Interest on Bonds. Per Cent	Per Cent Cost of System as Assessed on Abutters
Arlington, Mass.			$288 372.23 (a)			$288 372.23 (a)	$114 500.00		4	45½
Fitchburg, Mass.		$1 500.00	384 568.41			384 568.41	78 450.00	$28 000.00	3½	75
Gardner, Mass.			230 546.63		$62 108.00 (d)	292 014.63			3½	96
Haverhill, Mass.										75
Hyde Park, Mass.							103 000.00		4	50
Laconia, N. H.			120 000.00			120 000.00	117 000.00		4	
Lawrence, Mass.			1 156 152.00			1 156 152.00	175 000.00		4	22½
Marlborough, Mass.	$11 480.00	10 400.00	353 129.37	$600.00 (j)	38 611.06	392 340.43	257 000.00	182 654.38	4	
Nashua, N. H.										
New Bedford, Mass.						1 165 508.00	815 000.00		3.90	50 of lat. sewers
New London, Conn.			359 880.72				67 000.00		4	
Newton, Mass.	51 210.00	18 000.00	1 765 816.38	6 700.00		1 772 516.38	1 350 000.00	652 811.00	3.916	37
Pawtucket, R. I.	34 275.00	131 901.13	982 920.98			982 920.98	575 000.00	131 901.13	4	21½
Plainfield, N. J.	8 997.00	(f)	179 376.00		143 487.00	322 863.00	125 000.00 (g)	68 000.00 (h)	4	
Springfield, Mass.			1 345 378.78			1 345 378.78	253 000.00	66 218.24	3½	25
Waltham, Mass.	31 812.45	9 250.00	420 620.35		Incl.	420 620.35	201 000.00	75 240.00	4	50
Watertown, Mass.			274 575.29		Incl.		70 000.00		4	
Westfield, Mass.			350 602.72			350 602.72	142 000.00		4	
Worcester, Mass.	68 933.00	47 656.08	4 011 936.42	28 036.15	630 000.00	4 669 972.57	1 721 000.00	541 167.81	3½	33.5

[1] Includes payment for maintenance of joint disposal works. (a) Including maintenance to date. (b) Includes deficit of $707.75 for 1905. (c) Expended for hose. (d) Includes $10 947.00 for ½ acre coke strainers. (e) Rentals. (f) Bonds retired, $4,000. (g) Sanitary sewers only. (h) Bonds substituted for outstanding notes. (i) Includes $1 397.98 for litigation on account of purification. (j) Pumps only.

Hyde Park, Mass. Cleaning is done in part by flushing, and partly by the use of the Healey sewer cleaning machine.

Laconia, N. H. The sewers are cleaned by flushing through connections with city water mains.

Lawrence, Mass. Cleaning is usually done by hand.

Marlboro, Mass. The Healey sewer cleaning machine is used to some extent. Otherwise the cleaning is done by flushing through connections with city water mains.

Nashua, N. H. Very little cleaning is necessary. Most of it is done by hand or with Felton's sewer cleaning rods.

New Bedford, Mass. Cleaning is effected by flushing through connections with city water mains. Sometimes the pipes have to be dug up, but this occurs very seldom.

New London, Conn. The pipes are cleaned by means of a bucket hauled through them from one manhole to another.

Newton, Mass. Cleaning is in charge of an inspector who has a small force of men under him, He inspects and cleans the sewers as occasion may require, most of the work being done in the winter months. Grease and sludge are removed by brushes with the aid of flushing. Sand and gravel are removed by cylindrical scrapers.

Pawtucket, R. I. The sewers are cleaned by flushing through connections with city water mains and by means of a brush drawn through the sewer from one manhole to another.

Plainfield, N. J. The cleaning is effected by means of buckets and root cleaners which are drawn through the sewers on the end of jointed rods or a rope.

Springfield, Mass. Cleaning is done by means of scrapers and by flushing through connections with city water mains.

Waltham, Mass. The sewers are cleaned by means of scrapers drawn through them on the end of a rod or chain.

Watertown, Mass. The cleaning is done by means of brushes and other ordinary sewer cleaning tools.

Westfield, Mass. The Healey sewer cleaning machine is used.

Worcester, Mass. When large sewers need cleaning a sectional track is laid and the silt removed in pails to the manholes where it is hoisted out and placed in carts. In small sewers scrapers are used which are pulled through them from one manhole to another, by men, horses, or a hoisting engine, as circumstances may require. A hoisting engine has proved the most economical when it was practical to use it.

Assessments. — Methods of assessing the abutters and the rates of assessment have also been reported. The custom commonly followed in this matter of assessment appears to be that of charging the abutters according to the length of frontage along the line of sewer together with a certain amount per square foot on all land within a given distance of the street line. The rates of assessment in municipalities which have adopted this method are as follows:

City or Town.	Assessment.				
	Frontage (per Linear Foot).	Area (per Square Foot). To a Depth of			
		70 Ft.	100 Ft.	150 Ft.	180 Ft.
Arlington, Mass.	$0.28		$0.0052		
Fitchburg, Mass.	0.54–.084				
Haverhill, Mass.	0.20			$0.0040	
Hyde Park, Mass.	0.47	$0.0050			
Lawrence, Mass.			0.0065		
New London, Conn.	0.50		0.0070		
Newton, Mass.	0.15				$0.0055
Pawtucket, R. I.	0.25		0.0050		
Waltham, Mass.	60%			40%	
Worcester, Mass.	1.00–1.25				

In Gardner, Mass., the assessments are based on the extent to which the sewers are used by the abutters as well as on the length of frontage along the line of the sewer.

In Laconia, N. H., a level charge of $5.00 per house is made and the householders have to pay the cost of the connection as well.

In New Bedford, Mass., one half the cost of lateral sewers is charged to the abutters in proportion to the value of the land to a depth of 100 ft. from the street line.

At Springfield, Mass., the charge is $1.50 per front ft. for business blocks and $25.00 per dwelling house.

In Plainfield, N. J., the assessment consists of one half the average cost of laying an 8-in. sewer levied on abutters on each side of the street according to their length of frontage.

In Watertown, Mass., the cost of the house connections is paid by the property owners for work done within their premises. The cost of the work within the street lines is paid by the town.

OBITUARY.

William Vaughan Moses.

MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

WILLIAM VAUGHAN MOSES, the son of Dr. Thomas Freeman Moses and Hannah Cranch Moses, both of New England birth and ancestry, was born in Springdale, near Cincinnati, Ohio, on April 20, 1869. His parents moved the next year to Urbana, Ohio, where his father became professor of natural sciences at Urbana University.

Obtaining his preparatory education in the Urbana schools, William entered the University of Michigan, took the course in Mechanical Engineering, and graduated in the class of 1889.

After graduation he spent four years in Cleveland and Philadelphia with S. T. Wellman, working on the design and construction of blast furnaces and steel-making machinery. In 1893, he came to Cambridge and was appointed instructor in Mechanical Drawing and Machine Design at Harvard University, a position he held for eight years. At the expiration of this time he resigned to re-enter active professional work. After a year spent with the Wellman Seaver Engineering Company, as superintendent of construction on a foundry and furnace plant in Columbus, Ohio, he entered the Case School of Applied Science at Cleveland and took a year's course in electrical engineering. The following summer he visited England, and on his return in the fall of 1903, he entered the service of the General Electric Company at Lynn, Mass., where he was engaged in the design of steam turbines and where he remained until the time of his death.

In 1896, he married Mabel B. Snow, of Cambridge, Mass., who, together with his parents, four brothers and a sister, survive him. The illness which caused his death on April 14, 1908, was due to an ulcer of the stomach, and lasted but a short week.

Kindly of heart, modest and upright in character, a stanch friend, he lived a simple life, ever faithful to his duties, and to the tenets of the faith he held, that of the Swedenborgian or New Church.

F. LOWELL KENNEDY, *Committee.*

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PLANS, SPECIFICATIONS AND ESTIMATES OF THE COST OF BUILDING IN DETROIT AN EXACT DUPLICATE OF THE GREAT PYRAMID OF GIZEH.

BY E. S. WHEELER, MEMBER OF THE DETROIT ENGINEERING SOCIETY.

The President and Members of the Society: I wish to make some justification of, or if that is not possible, some apology or excuse for, the paper I shall read to-night.

First, I am older than the most of you and some privileges go with age; again, you either intentionally or inadvertently made me your president. In addition to the salary, there are certain privileges, exemptions and liberties that go with the office, and to-night I shall claim them all.

You members of the Engineering Society are busy men. James J. Hill once said to me, "Engineers have my highest regard; they are the men that do things." *You* are the men that are doing things in Detroit. If you should stop doing things, the city would be without buildings, without roads, ships or transportation, without light, without water and almost without hope. Each one of you has his special work and is pushing it with the most approved theories and the latest appliances. If a new and valuable discovery is made in your special field it must not be a month, or a week or a day old before you are using it for its full value, and not infrequently you furnish the new thing yourself and lead the advance. Now when any of you prepare a paper for this society it is informed with the best theories, latest results, numberless experiments, crucial tests, exact weights and measures, and your own final conclusions. To listen to and grasp such a paper require alert faculties

and close attention. Sometimes it makes me dizzy, and I get behind and am dissatisfied because my wits are not nimble enough to keep up with the theme and its logic and my memory is not comprehensive enough to retain the results. I remember that "all work and no play makes Jack a dull boy"; therefore that we may have some play mixed with our busy days, I have prepared a whimsical paper that will not require close attention or logical analysis, but rather the free use of fancy and imagination, and while it may *bore* you to listen to it, it will not *tire* you to understand it. I will say in advance that the paper has no purpose and will be entirely useless to you modern, practical, hustling engineers. The paper is entitled "Plans, Specifications and Estimates of the Cost of Building in Detroit an Exact Duplicate of the Great Pyramid of Gizeh." The present condition of the Egyptian pyramid is so nearly complete that numerous and exact measurements of all its parts have been made, so that the character and amount of all the material can be correctly given. The cost of labor and material for the Detroit pyramid will be estimated for this locality and the present time, and should be as nearly correct as estimates of the cost of large masses of masonry usually are. I shall call upon imaginations, yours and mine, for the scenes surrounding the Egyptian pyramid at the time of its building. I shall call upon fancy, yours and mine, for the methods, time and cost of building the old pyramid. I shall also call upon imaginations, yours and mine, to depict the appearance of the Detroit pyramid after it has been completed. In this the artist has aided our imaginations by giving us one view of the pyramid as it will appear from the deck of a boat in the middle of the Detroit River.

The selection of a site for the Detroit pyramid is first in order. It should be historic ground; therefore the place of Cadillac's village of 1701, the site of the fort that was besieged by Pontiac in 1763 and surrendered by Hull in 1813, has been chosen. The map, Plate I, shows the location with respect to the modern streets and buildings. The earliest authentic picture of this locality is shown on Plate II; its date is 1796. This picture and the maps were obtained from Mr. C. M. Burton, who is with us this evening. I will ask Mr. Burton to give you a few moments' talk upon their origin and authenticity. [Mr. Burton said: "The picture, Plate II, is an inset on a map of Detroit River, made in 1796 under the direction of General George Henry Victor Collot, an officer in the army of Napoleon. The original map was until lately hanging in the Department of Marine in the

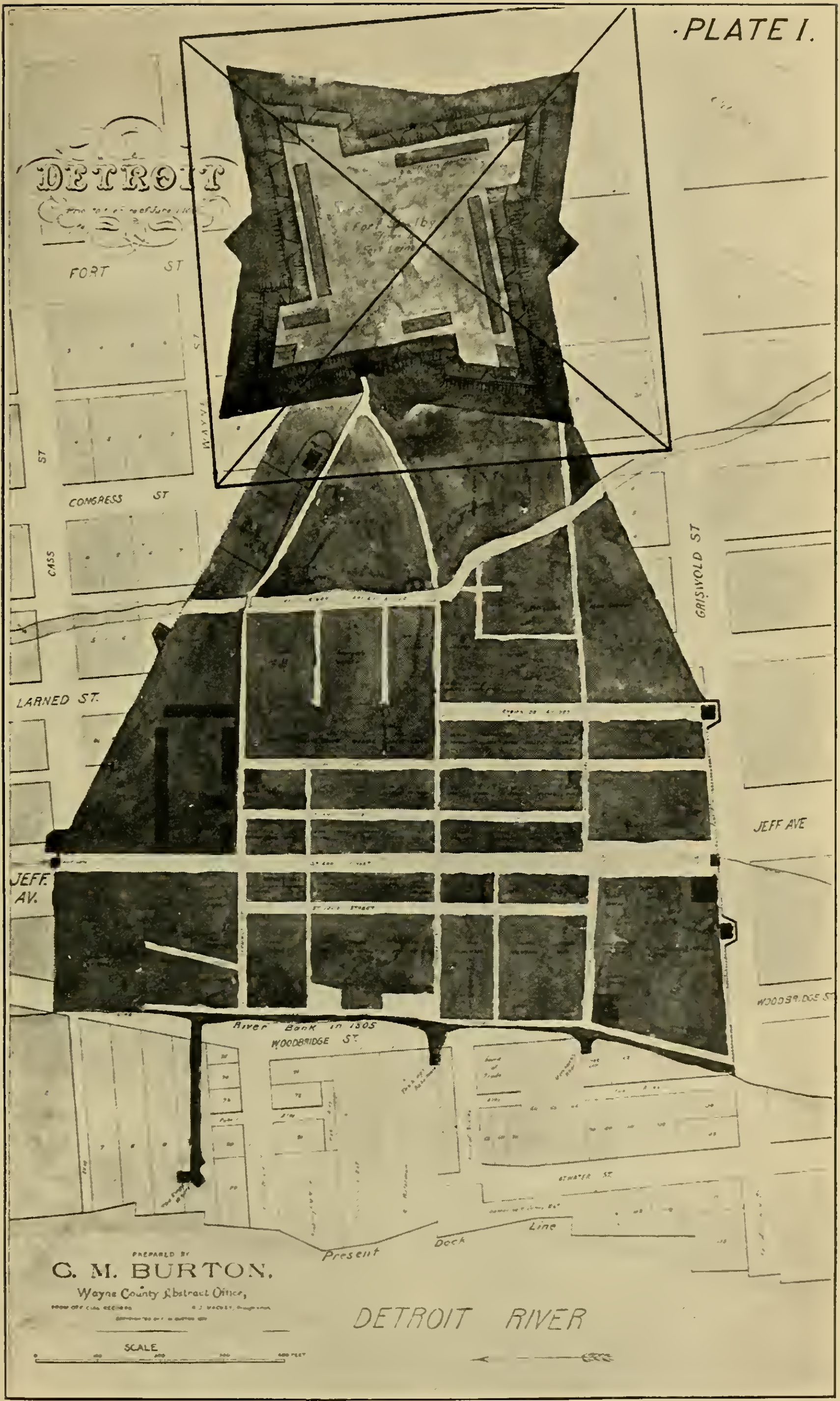


PLATE I.
DETROIT
FORT ST
WAYNE ST
CONGRESS ST
CASS ST
GRISWOLD ST
LARNED ST.
JEFF AVE
JEFF. AV.
WOODBRIDGE ST
River Bank in 1805
WOODBRIDGE ST.
Present Dock Line
PREPARED BY
C. M. BURTON.
Wayne County Abstract Office,
SCALE
DETROIT RIVER

PLATE II.

DETROIT IN 1796.

PYRAMID AS IT WOULD APPEAR IN DETROIT.

city of Paris. A description of it is given in Parkman's 'Conspiracy of Pontiac.' "] A copy of the map is in possession of Mr. Burton. The map, Plate I, was compiled from early maps, descriptions found in old deeds, locations of streets, etc. [Mr. Burton exhibited a thick portfolio of original documents, all dated in the seventeenth century, many of which were used in the preparation of the map.] For these historical reasons the site finally chosen is as shown on the map, Plate I. The apex of the Detroit pyramid will be directly above the intersection of Fort and Shelby streets, and since the base of the pyramid is 759 ft. square, the structure will occupy something more than the four blocks that corner on Fort and Shelby.

The second thing in order is the foundation. The pyramid of Gizeh is built on solid rock. In order to have the Detroit pyramid equally stable, it will be necessary to build a foundation of concrete down to the rock, which is here about 120 ft. below the surface. A prism of concrete 759 ft. square and 120 ft. deep would contain about 2 600 000 cu. yd. The cost of such a foundation and a site will not be considered here, because it is believed that by the time our finances are in such a shape that the Society can without inconvenience present Detroit with such a pyramid, the city will contribute the site and foundation. We can now proceed with the specifications and estimates of the pyramid proper.

The first paragraph of the specifications is as follows: "The Detroit pyramid shall be a complete and exact copy of the pyramid of Gizeh as it was when first built and before it had been broken into and desecrated by early barbarian kings or later civilized antiquarians. The material of the Detroit pyramid must, where possible, be the same as that of the old; if not, it must be equally good, as determined by the Detroit Engineering Society."

This paragraph practically covers all of the requirements. The remaining one hundred and eight paragraphs merely describe the details of the old pyramid and prescribe them for the new. I will, therefore, not read them, but give a brief description of the old pyramid, so that you will readily understand what the remaining specifications must necessarily be. Plate IV is a section through the old pyramid. The cutting plane is vertical, parallel to the east and west sides, and 24 ft. west of the center. It happens that this plane passes through all of the rooms and passages that were originally built in the pyramid. There are some forced passages and excavations made by explorers and

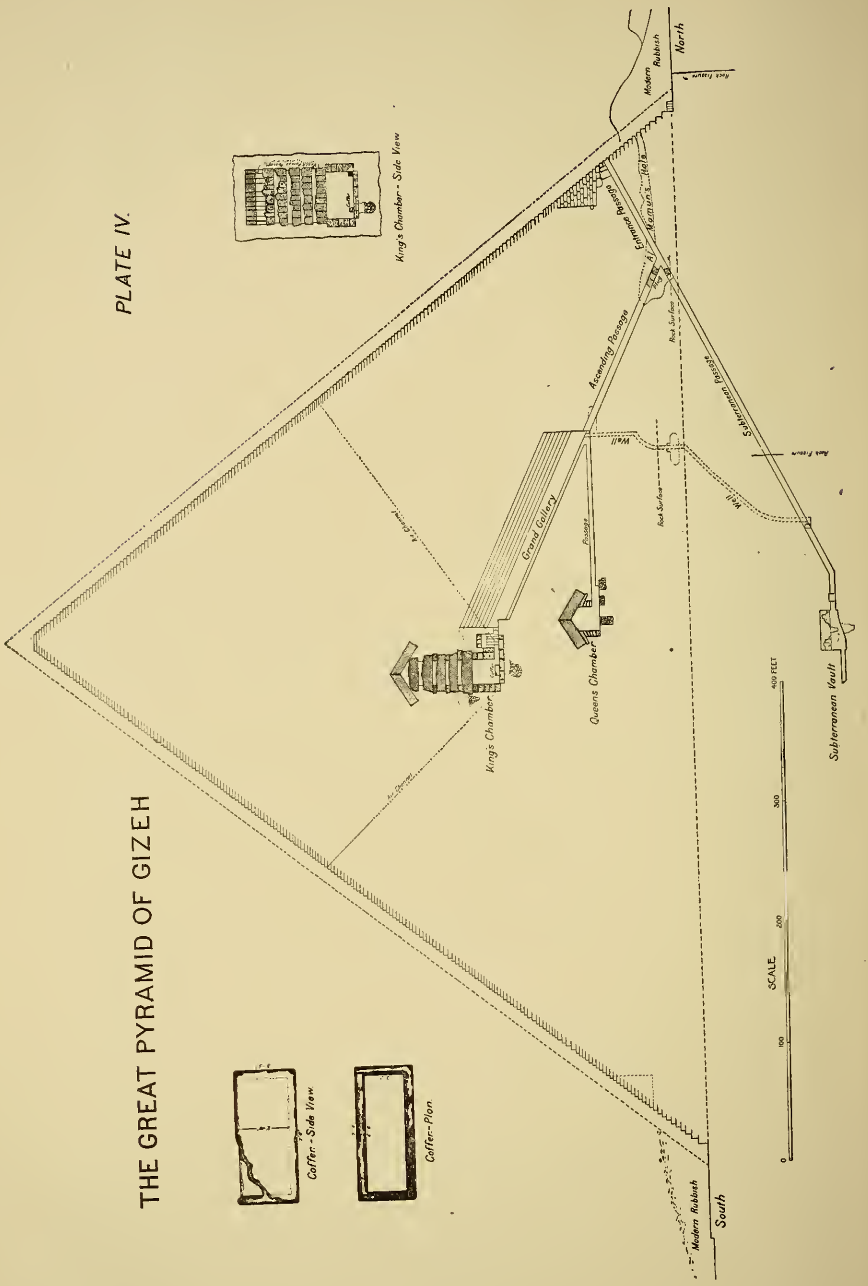


PLATE IV.

THE GREAT PYRAMID OF GIZEH

marauders which are not wholly in this plane. These will be described later.

The entrance is on the north side, about 60 ft. above the base and 20 ft. east of the middle. The entrance passage is about 3.5 ft. wide and 4 ft. high, and descends at an angle of 26 degrees. The first 105 ft. is through the masonry of the pyramid. The remaining 270 ft. has been quarried through the living rock. The lower end of this passage opens into the eastern side of a chamber called the "vault" and passes beyond it a distance of about 50 ft. when it stops abruptly and in an apparently unfinished condition. This chamber is 28 ft. wide, 46 ft. long, and averages about 8 ft. high. It is rough, unfinished, and resembles a portion of a deserted mine. Its center is directly under the apex and 100 ft. below the base of the pyramid. In the Detroit pyramid this chamber will be 100 ft. below the pavement of Shelby and Fort streets. You will see by the drawing that it will be about 80 ft. below the surface of the river. It will be entirely in the concrete foundation. This is the only part where the Detroit pyramid will differ from the old one. For some reason this room was left unfinished in the old pyramid. I think we will have ours neatly finished and decorated, so that the treasurer of the Engineering Society can use it for a quiet place to count his money.

About 90 ft. from the entrance the ascending passage begins. It opens through the roof of the descending passage, is of the same size and rises at the same angle, and lies in the same vertical plane.

After a distance of 128 ft. this passage divides into two, one of which continues southward, horizontally, for 126 ft., where it enters a room known as the "Queen's Chamber." The other part continues on in the original direction, but its height is suddenly increased from 4 to 28 ft. Through this part of its course it is called the "Grand Gallery." After 157 ft. it terminates in a low, horizontal and somewhat complicated passage, which leads into the principal room of the pyramid, known as the "King's Chamber." This room is 17 ft. wide, 34 ft. long and 19 ft. high. The roof is flat and covered with granite slabs or beams which reach from one side to the other. The sides are also of granite slabs. In the west side of this room stands a heavy stone box, believed to be a sarcophagus. The present condition of the sarcophagus is shown in this sketch. It is made from one solid block of red granite. The mutilating has been done by modern Vandals. The part that is left is not cracked,

but will ring with a clear bell-like tone when struck with a stone or hammer. Sides and end walls are 7 to 8 in. thick. The cover is gone. There is a groove in the box which shows where the cover was formerly slipped into place. There are also shallow holes in the edge of the box, which are believed to be part of the lock.

On the north and south sides of the chamber are two small passages leading to the open air. They are about 8 in. square, and, unlike the larger ones, rise at angles of 33 degrees and 46 degrees. They are believed to be air channels and designed for ventilation only.

Above the King's Chamber are five small chambers. The lower one is called Davison's Chamber and the upper ones Vyse's Chambers, in honor of their discoverers.

It is supposed that they are interstices in the masonry left by the builders, so as to partially relieve the roof of the King's Chamber from the weight of the superimposed masonry.

To the builders of the pyramid the arch was unknown, hence they resorted to this clumsy substitute. What was gained by the first four of these chambers is not very evident to the modern engineer. If they are only intended to serve the purpose of an arch, it would seem that the fifth or last chamber, which is made of long stones leaning together at the top like rafters, might have been placed directly above the King's Chamber as well as in the position it now occupies. The rough and unfinished character of these chambers proves that they do not form a part of the plan of the pyramid, but are simply an accident of construction. These chambers are inaccessible at present.

The Queen's Chamber is 70 ft. below the King's. It is 19 ft. long, 17 ft. wide and 20 ft. high. The roof is pointed and is formed of two sets of stones leaning together at the top like rafters. In the east side is a niche, shaped something like a church window. It is 15 ft. high, 5 ft. wide and originally 3.5 ft. deep. Now it is much deeper, explorers having dug some distance into the back wall in search of treasures.

The Queen's Chamber is also provided with air channels similar to those in the King's Chamber.

In the bottom of one of these air channels was found a small bronze hook and a round stone. It is supposed that some early explorer found the exterior opening and let the hook down with a string to the bottom to see what he might bring up. The round stone was attached to carry the hook down, and both were lost by the breaking of the string.

These are all the passages and chambers yet discovered in the Great Pyramid which were made by the builders. All of the passages, whether for entrance or for ventilation, are inclined to the horizontal at nearly the same angle, and are in nearly the same vertical plane, which plane passes exactly north and south through the pyramid and about 24 ft. east of the middle or apex.

Besides these there are other passages made more recently by explorers, which are simply irregular holes quarried or burrowed through the solid masonry in search of hidden chambers and treasures. They can never be mistaken for the straight, well-lined and polished galleries and chambers made by the builders.

The largest of these forced passages is called "The Well." It begins in the lower end of the Grand Gallery and descends to the vault. Its size is irregular and its course crooked, as if the workmen when excavating it had varied their course from side to side in search of easier digging. It is not known by whom this passage was made. It is now choked with broken stones so as to be entirely inaccessible.

There is another passage called "Al Mamun's Hole," which begins at the middle of the base at the north side of the pyramid and goes in horizontally for about 125 ft.; it then turns sharply around to the east for about 20 ft., and breaks into the descending passage just at the point where the ascending passage begins. It is now partially choked at the exterior with débris so that it cannot be entered, but a perceptible current of air passes through it into the descending passage. It was made by the caliph, Al Mamun, in the eighth century. At that time the true entrance to the pyramid was unknown.

Al Mamun ordered it to be broken up. His workmen began at the base of the pyramid and in the middle of the north side, which point is 60 ft. below and 20 ft. west of the true entrance. After proceeding horizontally 125 ft. towards the center of the pyramid they were on the level with and 20 ft. west of the descending passage. Their mining had so shaken the masonry near them that one of the roof stones of the descending passage fell with a noise loud enough to be heard by the workmen, who immediately turned to the left in the direction of the sound, and after going 20 ft., broke into the descending passage. They then found that the stone which had fallen was the one which had entirely closed up and concealed the entrance to the ascending passage. They also found that this passage was still firmly blocked by a huge granite portcullis, or plug, which entirely

filled it, and that the descending passage was blocked a few feet lower down by a similar portcullis. After vainly attempting to remove these two stones, they found it easier to mine through the masonry around them and break into the passage in their rear. This was done and the two granite blocks still remain in their original position, the explorer now using the excavation made by Al Mamun to get around in their rear.

What Al Mamun found when he did finally arrive in the King's and Queen's chambers is not known. There are the usual Arab tales of gold and gems and enchanted lamps.

One tale is that the splendor of two gems in the King's Chamber made the first five Arabs who entered totally blind, and that finally the caliph had two blind men wrap the two precious stones in thick cloth and carry one of them to the east and the other to the west side of his kingdom. After they were so far separated it was just possible for human eyes to look on their brightness. It is, however, almost certain that the caliph found the chambers much as they are now. They were probably rifled and despoiled much earlier in their history.

It is probable that those unknown explorers who made the mysterious well were earlier than the caliph, and it may be that they carried away the secrets of the Great Pyramid.

Besides these two principal passages there are several shorter ones forced through the original stone work. Col. Howard Vyse broke from the King's Chamber into all five of the smaller ones above. A hole 3 or 4 ft. deep has been dug below the spot where the sarcophagus used to stand, and generally every stone that could be forced out of place, chiseled, broken or defaced has been so treated.

All that part of the descending passage below the entrance to the ascending passage is choked with broken stones, so that it and the vault are now inaccessible.

The material of which the Great Pyramid is built is limestone, quarried near by, and similar to the rock on which it stands.

The galleries and chambers are lined with red granite, and a kind of white limestone quarried at Mokattam on the east bank of the Nile.

The only hieroglyphics ever found about the Great Pyramid were discovered by Col. Howard Vyse in the interior of the construction chambers. Those were made with red ochre on the rough, unfinished sides of the stones, and are supposed to be simply quarry marks for the convenience of the workmen. They were evidently put on with a brush, much as boxes are now

marked for transportation. Champollion says that they belong to the earlier hieroglyphics.

It is supposed that the exterior of the Great Pyramid was originally cased, or covered, with Mokattam limestone, similar to that used in lining the galleries and chambers, and that this casing has been stripped off and carried away by the caliphs who ruled Egypt one thousand years ago.

Col. Howard Vyse, in removing the rubbish on the north side, found two of these stones in their original position. One of them has since been placed in the British Museum. Their outer surfaces were highly polished and the joint between them microscopical.

At the corners of the Great Pyramids can be seen shallow excavations in the rock from which the corner casing stones have been removed. Among the débris that surrounds the pyramid can be found many angular fragments of limestone corresponding in shape to the acute and obtuse angles or edges of the existing casing stones. These and many other reasons make it almost certain that the pyramid was originally cased, that its sides were plane and polished, and its top, instead of being truncated as now, terminated in a point. This would make the original dimensions of the pyramid as follows:

Length of side, 760 ft.; height, 485 ft.; area of base, 13.25 acres. At present the length of the sides is 746 ft., the height 454 ft., and the area of the base 12.75 acres.

Such is a general outline of the present condition of the Great Pyramid, with which the Detroit pyramid must exactly correspond.

It is believed by most authorities that all the pyramids were built and used as tombs, probably of kings, and for no other purpose.

There have been many other theories suggested, such as their having been designed for treasure houses, granaries, astronomical and scientific stations, masonic temples, fortifications, etc. But none of these theories is believed to be sustained by appearances, though some have been urged with much ingenuity by their inventors. Some of the most obvious proofs of their being tombs are: they are surrounded by numberless smaller monuments that are known to be sepulchers; hence standing in the midst of a cemetery their location is a strong indication of their use. The stone box in the King's Chamber resembles many of the sarcophagi taken from tombs. All entrance to the interior was permanently closed by the builders, a

thing which would most likely be done if they were tombs, but could hardly be possible if they were intended for any other of the uses ascribed to them. They are found in groups; so also are tombs; but observatories, temples, etc., are usually isolated and single.

It has been mentioned that there are no graven hieroglyphics on the pyramid. It is true there may have been on the casing stones that have disappeared, but since no trace has been found among the fragments that surround the pyramid, nor on any of the casing stones that still remain, it is probable there never were any. The inscriptions found by Sir Howard Vyse in the construction chambers prove that hieroglyphics were in use at the time of the building.

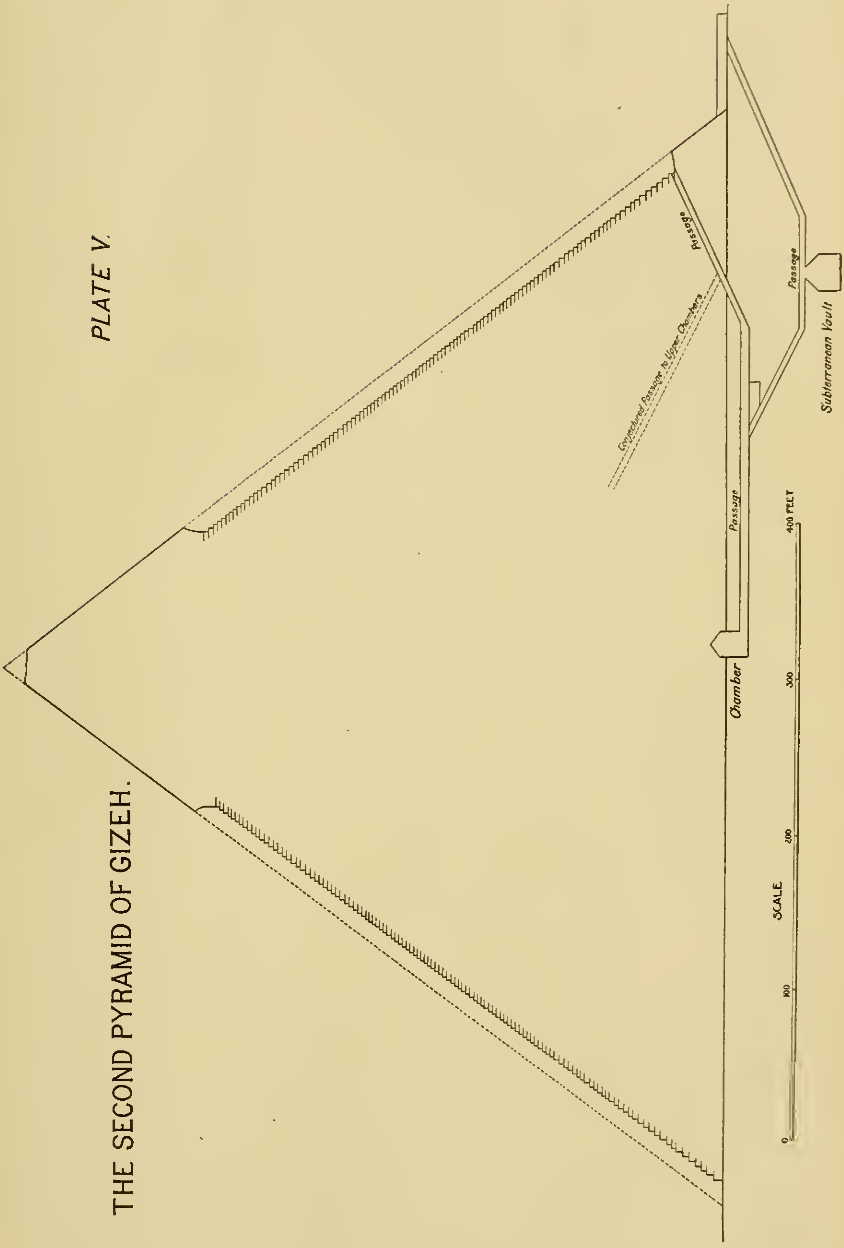
The age of the pyramids is a question which antiquarians have tried hard to answer. Not less than six thousand years seems now to be the general opinion, while none doubt the possibility nor even the strong probability that they may be much older.

Herodotus makes the first mention of them that is considered at all authentic. He visited them 2 300 years ago and found them much as now, except it is probable that the casing of all of them was entire and the upper system of chambers in the first one unknown.

When Champollion partially succeeded in reading the hieroglyphics, it was hoped that the age of all existing inscribed monuments would become known. But this was not the case. It is true that the relative age of many of them was pretty certainly determined, but the interval of time which separates Egyptian chronology from the Christian era is a matter upon which hieroglyphics give no exact information. It has been thought by some that the angle of inclination, which is common to many of the passages in the first and second pyramids, might have an astronomical significance. For example, the latitude of the pyramids, or the elevation of the pole at that point, is a little less than 30 degrees. The direction of the entrance passage being very nearly north and south, and its angle of elevation a little more than 26 degrees, it is apparent that this passage points to a spot in the heavens about 3.5 degrees below the pole. If the entrance passage had been elevated 3.5 degrees more, so as to point directly to the pole, it would seem probable that the existence of the pole was known to the builders, and that this fact decided the angle of elevation. But since the passage points about 3.5 degrees below the pole it was thought by Sir

PLATE V.

THE SECOND PYRAMID OF GIZEH.



William Herschel that this might have been the place of the lower culmination of the pole star of the period. He, therefore, computed what bright stars had been 3.5 degrees from the pole at different times. His results were not convincing and the problem is yet unsolved. It is possible that the pyramids do yet contain within themselves some clews that will, when found and rightly interpreted, reveal their age.

Are they really wanting, or do they exist and are simply undiscovered? If another Caliph Al Mamun should shake the masonry of the second pyramid about 100 ft. from the entrance, would not another "triangular" stone fall and leave exposed another opening leading to upper chambers and galleries, the same as in the first pyramid?

Professor Smyth discovered and noted that the joints in the floor of the descending passage of the first pyramid were at right angles to the passages, with the exception of two which were marked diagonal. These two were directly under the lower end of the ascending passage. The space in the roof that was once occupied by the stone that Al Mamun's men shook down, also shows that the roof had two diagonal joints as well as the floor.

Professor Smyth attaches a symbolic signification to these joints. It may be, however, and is quite probable that these two stones were the last to be put in place, and were cut wedge shaped, so that they could be forced in from opposite directions, and so make these last joints as close and perfect as the others. But whatever may have been the cause or need for these diagonal joints, it is a fact that they do exist in this one place and nowhere else in the first pyramid.

If the second pyramid has an ascending passage it is possible that similar joints mark the place of entrance.

This description will for the purposes of this paper take the place of the remaining specifications. Before proceeding with the estimates I will speak for a moment of a theory or fancy of my own in connection with the second pyramid. This pyramid stands near the great pyramid, is of about the same size, and in many respects resemdles it. For example, the azimuths of its sides are the same within half a minute, the inclination of the entrance passage is also the same within a few seconds. The geometrical figures of the two pyramids are the same. These points of similarity might lead one to infer other agreements. Plate V shows a section through the middle of the second pyramid. This passage is believed to belong to a small and older

pyramid which has been completely covered by the larger one. It will be noticed that the upper chambers and passages are wanting in the second pyramid.

During February, 1872, I made a visit to the second pyramid to see if there were any indications of an upper series of chambers. At the point where the examination was to be made it was found that the passage was half choked with débris from the exterior, so that the floor could not be seen at all, but the roof could be examined, and in the precise place expected there was found a single diagonal joint. All the other joints in the entire passage were at right angles to the passage. The diagonal joint seemed to have originally been a very fine one, but a settling of the masonry had cracked it open until it was about 1-16 of an inch in width. One small fragment of the stone had been so firmly cemented that it had broken off from one stone and adhered to the opposite one, showing that the original joint could not have exceeded .02 of an inch in thickness.

After making this observation I called upon Mariette Bey, who had charge, under the khedive, of all the excavations in Egypt, and tried to obtain permission to make the necessary examinations in the second pyramid. This was not granted. Mariette Bey at that time was not disposed to let foreigners interfere with a department peculiarly his own. He was especially incensed with Mr. Dixon, who had made his researches and discoveries secretly and in the night time, and had succeeded in carrying away from the country several things which Mariette Bey thought of right belonged to his museum at Boolaque. He, however, listened with interest to the theory of upper chambers, and said he would make the necessary examination when he should again organize a party and take the field for the purpose of making excavations. He also promised to notify me of the time of beginning the work and the results attending it. Nothing has yet been heard from him, and as he has been dead for a considerable time, nothing much is expected.

If a system of upper chambers and galleries should be discovered in the second pyramid, it is barely possible that they may be found undisturbed as they were left by the builders, but it is probable that if found at all, they will be found rifled and despoiled.

The classification of material of the Great Pyramid is very simple. It is built entirely of stone, and but three varieties were used. The great mass of the pyramid, or backing stone, is a coarse limestone, which was quarried from the nearby hills and

was not moved more than a thousand yards. There is 3 313 000 cu. yd. of this material, or about 96 per cent. of the volume of the pyramid. It was quarried or sawed in blocks, having dimensions of from 2 to 13 ft. There were few of the large blocks; 90 per cent. of those that are visible have no dimension greater than 5 ft. They were laid in good quality of mortar. The joints are not close; there are some 3 or 4 in. wide that are filled with broken stone and mortar. The material is about the same as that of the "backing" of the Poe Lock, which was quarried at Drummond's Island.

The outer casing and lining of the passages and Queen's Chamber is a fine-grained limestone, recognized as coming from the quarries at Mokattam on the opposite side of the Nile and about sixteen miles distant. The blocks are generally large, the dimensions ranging from 2 to 10 ft. The most remarkable feature of this part of the work is the fineness of the joints. Most of them are microscopical. The quality of this limestone is about the same as that of the facing stone of the Poe Lock, which was quarried at Kelley's Island. The amount of this stone is approximately 140 000 cu. yd. About 2 000 cu. yd. of granite was used around the King's Chamber. This is recognized as having been quarried at Aswam, about 500 miles up the Nile. The Obelisk in New York is of the same material and was undoubtedly quarried at the same place. The granite work is shown around the King's Chamber, Plate IV. One forming part of the roof or ceiling is the largest known stone in the pyramid; it is 27 ft. long, 6.66 ft. deep, and 5 ft. wide, containing 33 cu. yd. and weighing 77 tons, approximately.

The joints in the sides and roof of the King's Chamber are microscopical. This is a fine red granite, probably not better than Vermont granite.

For the Detroit pyramid there will be needed:

Backing stone, coarse limestone,	3 313 000 cu. yd.
Facing stone, fine limestone,	140 000 cu. yd.
Facing stone, fine granite,	2 000 cu. yd.

The backing stone at the Poe Lock cost $8.50 per cu. yd. The contractor's profits were only fair, and it is believed that this price is a safe and close estimate for the Detroit work. Therefore the backing stone for the Detroit pyramid will cost $28 160-500. The face stone at the Poe Lock cost $28.50 per cu. yd. The only considerable difference between this and the pyramid facing stone is the fine joints in the latter. It is difficult to estimate the cost of making these fine joints, since no work of

this kind has been done near here, or anywhere else so far as I know, in the last six thousand years. It is believed by some that the blocks were ground together. It is known that very fine joints that will even exclude the air can be made by rubbing the stone together. In the absence of any precedent or knowledge whatever, I have assumed that such fine joints would double the cost; therefore the limestone facing is estimated at $57 per cu. yd., or a total cost of $7 980 000.

It is still more difficult to correctly estimate the cost of polished granite in large masses. It is therefore roughly assumed that such granite as is found in the Great Pyramid would cost in Detroit $100 per cu. yd. It happens the amount of granite is relatively small, so that a large error in its estimated cost would make but a small percentage of the total. The amount of the granite being 2 000 cu. yd., its total cost would be $200 000.

Collecting the items, the grand total is as follows:

3 313 000 cu. yd. backing stone @ $8.50, .	$28 160 500
140 000 cu. yd. facing stone @ $57.00,	7 980 000
2 000 cu. yd. granite facing @ $100.00,	200 000
Total,	$36 340 500

This estimate does not include cost of site or foundation. The Great Pyramid covers a little more than thirteen acres. I do not know if there is any other thirteen-acre lot in one rectangle on which thirty-six millions of dollars have been expended

Mr. Pool, director of the British Museum, says, " No monument of man's raising elsewhere affords any scale by which to estimate its greatness." Mr. Lewis, professor of architecture, University College, says, " The most gigantic work in the world; one which never has been and perhaps never will be surpassed." Thus far our computations and conclusions have tended to bring out and illustrate the vastness of the structure and its enormous cost. From another point of view it seems small, if not insignificant. Our Secretary has compiled certain statistics concerning the Calumet and Hecla mine. He finds that 19 000 000 cu. yd. of rock have been mined and crushed at a cost of approximately $101 000 000, equivalent to about three pyramids. The loss at the Chicago fire is estimated at $196 000 000, equal to about five pyramids. One of our past presidents is building a tunnel under the Detroit River that is expected to cost $8 000 000, about one fourth of a pyramid; he does not seem to mind it much. Finally, if a day's work is worth a dollar and a half, it

would require 24 000 000 days' work to build a pyramid. The population of the United States is about 80 000 000. It is reckoned that one in five is able to do a day's work; therefore there is available 16 000 000 days' work each day; it would take a day and a half to build a pyramid. If the United States should stop all other work and devote itself entirely to building pyramids, as was probably the case in Egypt, it would, after it got fairly running, be able to turn out two every three days.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 1, 1908, for publication in a subsequent number of the JOURNAL.]

DISCUSSION ON PAPER BY PROFESSORS WINSLOW AND PHELPS, "PURIFICATION OF BOSTON SEWAGE: EXPERIMENTAL RESULTS AND PRACTICAL POSSIBILITIES."

(Vol. XL, Page 28, January, 1908.)

Mr. M. N. Baker (*by letter*). — Both interest and value are added to any experimental investigation by conducting it as nearly as possible under everyday working conditions and by applying the small-scale results to a plan embracing large operations. In the paper under discussion we have an account of the experimental treatment, in miniature, of the sewage of a large city, followed by an application of the results obtained to estimates of the cost of treating a large portion of the sewage of the same city. Because a discussion of the possibilities of treating Boston sewage gives concreteness to the experiments, because there would doubtless be some present-day advantage in treating the sewage of Boston, and also because at some future day treatment may be imperative, the presentation of the scheme outlined in this paper is fully warranted. It seems to the writer, however, as though Boston has a dozen sanitary needs which should be met before money is expended on purifying its sewage, particularly if the purification were to be an attempt at disinfection. It seems perfectly safe to assert that dirty pavements cause far more sickness and loss of life in Boston every year than does the pollution of the harbor, while many times more sickness and death are caused there by dirty, disease-infected milk than by unclean streets and polluted tidal waters together.

Quite aside from what purification Boston sewage does or does not need, it is encouraging to learn that there is reason to believe that the sewage of a large American city might be rendered both non-putrefactive and non-infectious by such simple means and at so low a cost. Percolating filters alone may frequently prove sufficient where there is no objection to discharging suspended matter into a river or harbor, provided only the effluent is non-putrefactive. If a low-cost disinfecting agent, applied by simple and inexpensive means, has at last been found, as the authors of the paper believe, many of the sewage purification problems of the future will be greatly altered in character and reduced in cost. As a general proposition, and reasoning from experience in the treatment of both sewage and water by pre-

cipitants and by coagulants, it seems likely that disinfection alone will fail in either bacterial efficiency or in economy, and perhaps in both. In fact, it would not be surprising, if practical experience with the sewage of most cities should show that where the effluents of percolating filters are to be disinfected, intermediate sedimentation would be required.

MR. G. W. FULLER. — This paper is a distinct addition to the literature in this country upon sewage disposal and brings clearly to the front a gratifying confirmation of a number of the more essential developments which have recently appeared in this field of sanitary work and accentuates several points upon which further data are desirable or necessary.

The distribution of sewage over a filter of coarse stone even under conditions such as will secure efficient aëration, is no longer a feature to be dreaded, although it is clear that there are some details yet to be worked upon. It is gratifying to note that at the testing station of the Institute the authors found no serious difficulties in distribution either with the devices of their own design or with the Columbus nozzle. It seems to the writer that the distribution arrangement at the Albany Street Station has a number of serious handicaps from the standpoint that severe wind storms would likely interfere with its efficiency, whereas with the sprinkler nozzle the action of wind seems to assist materially in the uniform distribution of the spray.

At the small sprinkling filter plant on the Croton watershed at the Montefiore Home it has been found that an accumulation of grease, particluarly upon the front knife edge of the arms supporting the inverted cone, interfered somewhat with the distribution of the spray. It is also found there that the supporting arms must be stiff enough to resist bending, because if they become slightly twisted from the vertical, there is also some interference with the distribution. Taking everything into consideration, it is believed by the writer that the form of nozzle in use at Reading, Pa. (see *Engineering Record*, October 5, 1907), and resembling the first design gotten out for Columbus as stated by Mr. J. H. Gregory in the Trans. Am. Soc. C.E. for December, 1906, is preferable to the design which is generally spoken of as the Columbus nozzle and such as is used at the Albany Street Testing Station.

The writer agrees with the conclusions of the authors that there is no benefit in the operation of sprinkling filters with alternate working and resting periods of considerable length, now that it is assured that successful results may be obtained in

sprinkling filters constructed of stone much coarser than was used in the Columbus tests. The weekly resting periods at Columbus, it should be stated, were advocated with a view to reducing clogging, even at the sacrifice of nitrification, a point which was investigated at length by the writer at Lawrence in 1894, as described in detail in the report for that year of the Massachusetts State Board of Health. With the substitution of the coarser for the finer filtering material in the sprinkling filters the need for the longer resting periods from the Columbus standpoint practically disappears.

The statements in the paper coincide with the views of the writer in regard to the proposition that the septic effluent possesses no advantage due to the septicity which it has undergone. The writer is not prepared to accept, however, the general conclusion that unsettled sewage or unsepticized sewage may be treated as advantageously as sewage which has been clarified and thereby freed of a substantial proportion of its suspended matters and organic contents. It would seem that the Boston results have been obtained with rates and under conditions which do not fully and fairly show the point at issue as regards conclusions to be drawn from filters working side by side under full load. If the statement in the paper were true, it would be hard to reconcile the very striking fact developed in practice that the weak American sewages may be sufficiently filtered at rates materially in excess of those required for strong sewages, particularly those found in Europe.

Some injustice seems to be done coarse-grained filters in this paper according to the views of the writer as regards their hygienic efficiency. It is true that some bacteria will grow at enormous rates not only in septic tanks, but apparently also in sprinkling filters and in the basins in which sprinkling filter effluents are settled. Notwithstanding this, the bacteria entering the purification devices with the original influent are certainly responsive to the laws of subsidence, and it is believed that both in the filter and in the septic tank the removals amount ordinarily to 60 and 75 per cent. of the original bacteria, notwithstanding the fact that sometimes bacterial growths may show the effluent to contain several times as many bacteria as the influent. If our views as to the significance of the antagonism among different species of bacteria as developed in the Chicago Drainage Canal case are sound, then there is little reason to believe that disease germs are to be included among those species which grow within the purification devices in question. Un-

doubtedly there are cases in practice where purification is required to a degree greater than that ordinarily obtained by stone filters. But it appears to the writer that we ought not to draw conclusions to too fine lines from present evidence on this question of hygienic efficiency until the premises are more thoroughly discussed and agreed upon.

The work that is being done by Professors Winslow and Phelps at the Institute Testing Station along bacteriological aspects of these recently developed purification processes is certainly helpful, and it is hoped that they will have time and opportunity to continue their investigations upon points which evidently have not yet assumed their final stand and which give promise to be of much assistance in the future to those communities having sewage disposal problems to solve.

Prof. L. P. Kinnicutt. — I regret that I was unable to be at the meeting of the Sanitary Section at which the paper of C.-E. A. Winslow and Earle B. Phelps on "Purification of Boston Sewage" was presented, for it certainly was a most interesting and instructive paper, and one that had a very decidedly practical bearing; for though it may not be necessary to purify in any way for very many years the sewage of Boston before it is discharged into the harbor, the study that the authors have given to Boston sewage not only points out a method which, when it becomes necessary to treat Boston sewage, affords a comparatively cheap way by which sewage purification can be brought about, but also shows what can be done by cities where bacterial purification as well as the removal of putrescible organic matter is required.

The most interesting part of the paper, it seems to me, however, is the comparison of the work done by percolating filters on septic tank and on thoroughly screened sewage; and for the first time it has been shown that with sewage corresponding in character to Boston sewage, as good an effluent can be obtained from the screened sewage as from the septic tank effluent. This is certainly a decided advance in our knowledge of sewage treatment and may simplify the preliminary treatment of sewage which is to be run on percolating filters. It may even do more than this, for with sewage containing iron sulphate the septic tank action reduces the sulphate to sulphide, and when an effluent contains large amounts of iron sulphide, subsequent treatment is rendered more or less difficult. The rather poor results obtained with the experimental percolating filters at Worcester, I have felt have been at least partly due to the large amount of

iron sulphide in the liquor applied to the beds, and this I think receives confirmation by the results obtained by Winslow and Phelps.

If crude sewage can be run directly upon the percolating beds, all trouble caused by iron sulphide would be prevented. Whether or not the life of a percolating filter will be as long when crude sewage is used, and whether with such use the filter will not be more likely to puddle, can only be determined by further experiments, and by just such experiments as Professors Winslow and Phelps are now carrying on, and the continuation of their work will be watched with great interest.

Mr. G. C. Whipple. — The writer has followed the experiments that have been made at the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology with the greatest interest, as he realizes the value of such studies to the engineering profession. Never before has the sewage problem of Boston been so carefully studied with reference to its purification, and unquestionably when the time comes that some method of purification becomes necessary, the value of the experiments that have been made by Professor Winslow and Professor Phelps and their students and associates will be more thoroughly appreciated even than now.

The writer has little to say by way of discussion of the various topics that have been treated in the present paper. One thing, however, has particularly interested him, namely, the attempt to secure a proper distribution of the sewage by some form of sprinkler. The struggles that have been made thus far indicate that an entirely satisfactory form of sprinkler has not yet been secured. The method of testing the efficiency of sprinklers used by the authors and referred to in this and other papers is ingenious and the results are valuable. Continued study, no doubt, will result in the design of a sprinkler that will do its work properly. The results obtained at this station appear to be better than those which the writer has seen abroad, indicating that progress is being made in this important detail.

Another important feature of the experiment is the attention that has been given to the chemical disinfection of the partially purified effluents. The importance of this feature is becoming more and more apparent.

Not the least valuable of the functions of this experiment station is that of the education of young engineers. Here the students become accustomed to the use of the exact methods of analysis in solving the problems of sewage disposal. As these

students become scattered through the country and come in contact with practical problems, their influence will prove an important factor in the advancement of the art.

The publications on sewage disposal and sewage analysis that have emanated from this experiment station are already becoming numerous, and the writer suggests that it would be convenient for all interested if the authors would prepare a short summary of these various papers and keep a summary up to date by revising it from time to time. There are many engineers who are not interested in the details of the experiments who would be glad to have these general results briefly set forth. A summary of this character is very much needed for the work that has been carried on for so many years at the Massachusetts State Board of Health Experiment Station at Lawrence. Many valuable statistics and discussions are now scattered through nearly a score of volumes. Perhaps it is not too early to make preparations for the publication of such a summary which might be well termed "A Quarter Century of Experiments in Sewage Disposal."

The writer cannot help feeling that in the consideration of these modern schemes for the purification and disposal of sewage there is some danger lest the experience with the older methods be too much overlooked. In sewage disposal, as in other things, there are likely to be decided swings of the pendulum from conservatism to radicalism. Septic tanks and sprinkling filters are useful in their proper places, but they are not always the most desirable or the most economical forms of treatment to be adopted. There may be some danger lest the students in this laboratory become unduly interested in the newer projects. While, naturally, the experiment station must give its chief attention to new and untried methods, it should not neglect the historical and practical side of the subject as exemplified in the many sewage disposal plants already in operation. This, however, is looking at the work from a pedagogical standpoint.

The city of Boston is to be congratulated that such valuable information is being furnished to her without cost, and that there is being trained in her midst a group of men who will be well qualified to handle the problem of sewage purification when by reason of the growth of the city this becomes a necessity.

Mr. R. Winthrop Pratt. — The paper of Messrs. Winslow and Phelps is undoubtedly a most valuable addition to our knowledge of the subject of sewage disposal. The application of the results of the experimental studies to the problem of puri-

fying the sewage from the entire South Metropolitan District is especially interesting.

The problem of disinfection of sewage effluents is one of the most important phases in the work of sewage disposal at the present time. It already serves a valuable purpose in the work of public health officials. As referred to in the paper, the Ohio State Board of Health coöperatively with the United States Department of Agriculture has made somewhat extended investigations into the question of the use of copper sulphate and of chlorine for the disinfection of effluents from sewage works. The data thus secured have already been made use of in connection with the Board's action on proposed projects. The State Health Department of Pennsylvania has also advised or required that provision for disinfection, as a final treatment, be made in at least two cases that have come to the writer's attention.

One of the most important practical applications of the use of chlorine as a disinfectant on a fairly large scale was made last summer under the direction of the State Board of Health at Camp Perry, Ohio. Camp Perry is the new permanent encampment ground and shooting range of the Ohio National Guard, located on the shore of Lake Erie, near Port Clinton. Its construction was commenced last spring, and by August 1 the camp was occupied by two or three thousand men. These included not only the Ohio National Guard, but also rifle teams from the state militias of nearly all the states in the Union and from the United States Army and Navy.

A water supply system with water purification and a sewerage system and sewage disposal plant were provided, although lack of time prevented the entire installation being ready for the troops when they arrived. A main sewer conveyed the sewage from the entire camp to a receiving well, from which it was pumped on to intermittent sand filters having an area of one quarter acre. No preliminary treatment was given except screening and the small amount of settling which incidentally took place in the receiving well. As the treated sewage was discharged into Lake Erie within 600 or 700 ft. of the water supply intake, it was necessary that a high degree of purification be obtained. The sand filters alone, especially at the high rate at which they were operated, could not furnish a safe effluent.

As a finishing treatment, therefore, bleaching powder containing 34 per cent. available chlorine was applied to the effluent. The chemical was so proportioned as to provide for an application of available chlorine at the rate of 7.5 parts per million. The

period of contact of the chemical with the sewage amounted to 5 or 10 minutes. The results showed that the total numbers of bacteria were reduced from several millions to 100 or 200 per cubic centimeter, and most of the samples contained no B. coli. The cost of the bleaching powder was 4 cents a pound, and the cost per 100 000 gal. of sewage treated (which was approximately the average daily flow from the camp) was 75 cents.

Mr. George A. Johnson. — The paper by Messrs. Winslow and Phelps on the "Purification of Boston Sewage" is, indeed, a valuable addition to the literature on the subject of sanitary sewage disposal. It is such works as these that advance our comprehensive knowledge of the subject and are doing so much toward lifting the art of sewage disposal from the more or less experimental and indefinite state into the light of practicability and fact.

With regard to the necessity of preparatory treatment of crude sewage before it is applied to sprinkling filters, the writer cannot wholly agree with the conclusions of the authors as set forth in this paper. In his opinion it is clearly erroneous to assume that such filters operate quite as efficiently and economically where crude sewage is applied to them as when sewage is used from which the grosser solids have been removed.

Crude sewage from any community will always contain much paper and other non-nitrogenous matters in particles sufficiently fine to escape a ½-inch bar screen, yet coarse enough to clog a sprinkling filter in a comparatively short space of time. The writer's experience at Columbus, and his close observation of the working of sprinkling filters in England, have satisfied him that the efficiency and operating cost of a sprinkling filter, other things being equal, varies in quite intimate proportion as the completeness of the preparatory treatment of the crude sewage.

Mere screening of sewage does not, ordinarily, cause a very material reduction in the amount of suspended matter (10–15 per cent. with fine screens), while the advantage of sedimentation lies in the fact that from one half to two thirds of the suspended solids are removed in this way, leaving only suspended matter in a finely divided state, which is far less likely to choke the subsidiary filters. A large proportion of these grosser solids are non-nitrogenous, and are only destroyed or comminuted by anaërobic bacterial action, such as does not form a part of the action in an efficient sprinkling filter. These matters, therefore, must accumulate at or near the surface of such filters and there remain until removed by mechanical means.

In the case of Filter B at Columbus, which received sewage which had been screened through ¼-inch mesh screens and from which thereafter, in round numbers, 25 per cent. of the suspended solids was removed by sedimentation, surface clogging became so marked after eight months' operation at an average rate of about 2 000 000 gallons per acre daily, that the sewage pooled upon the surface, the quality of the effluent deteriorated because of this surface obstruction, and it became necessary to remove the upper three inches of material from the filter. Other sprinkling filters receiving settled or septic sewage did not call for such treatment during the tests. The filtering material used in this bed was composed of finer particles than that used by the authors (½ inch to 1¾ inches as against 1½ inches to 2 inches), and there is no denying that this fact probably had something to do with the speedy clogging of the filter. The fact, however, that this bed which showed surface clogging received sewage which contained 142 parts per million of suspended matter, and the beds which did not show such clogging received settled sewage containing but 82 and 76 parts per million of suspended matter, respectively, goes a long way toward convincing the writer that his views on this point are in general well founded.

The experience gained with sprinkling filters at the Lawrence Experiment Station is instructive in this connection. Mr. Clark,* in his review of the studies made under his direction, states:

"With filters 10 or 11 ft. deep . . . rates of at least 2 500-000 gallons per acre daily can be maintained and result in good nitrification and an almost invariably non-putrescible effluent. . . . It is possible when sewage has received preliminary treatment, as by sedimentation or septic tanks, to increase this rate materially. At present Filter No. 136, operating at a rate of 4 000 000 gallons per acre daily, and receiving a strong sewage, but one with much of the matter in suspension first removed by sedimentation, is giving a well-nitrified and generally non-putrescible effluent."

English engineers, with the exception of the late Colonel Ducat, are practically unanimous on the necessity of some form of preparatory treatment of crude sewage prior to its application to filters. The writer cannot call to mind one sewage disposal plant of size where crude sewage is applied to sprinkling filters; nor another case where such a procedure has been recommended for adoption in this country.

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* *Engineering News*, April 11, 1907, p. 399.

The authors direct attention to the accumulation of sludge in the septic tank during their experiments, stating that at the end of the first 12 months of operation the depth of the deposit therein amounted to 4 inches, and at the end of 20 months to 12 inches. From published figures the writer estimates that during the first year of operation the Boston septic tank stored about 0.45 cubic yard of sludge per million gallons; during the second year about 0.9 cubic yard per million gallons and during the total period of 22 months about 0.75 cubic yard per million gallons of sewage treated.

Similar results were found in the case of Septic Tank C at Columbus which, in 10.5 months' operation stored about 0.8 cubic yard per million gallons of sewage treated. This tank treated a total of 10 760 000 gallons of sewage which contained on an average of 149 and 43 parts per million of total and mineral suspended matters, respectively, and removed 46 and 49 per cent. of the above matters. It may be well to call attention to the fact that the sewage applied to the tank at Boston contained 135 and 44 parts per million of total and mineral suspended matter, respectively, a practical agreement with the sewage applied to the Columbus tank. The percentage of these matters removed was slightly greater at Columbus.

The writer wishes to point out in this connection that a rate of sludge accumulation in a septic tank not greater than 1.0 cubic yard per million gallons of sewage treated is not high, but decidedly the reverse. When treating the dilute sewages of this country, the volume of sludge requiring removal from a septic tank will ordinarily amount on an average to about 2.0 to 2.5 cubic yards per million gallons of sewage treated. Where such tanks are included in the purification system, and the bulk of the suspended matter is removed from the sewage in this way, the volume of deposit in the final settling basins receiving sprinkling filter effluent usually amounts to about 1.0 cubic yard per million gallons.

There probably exists no definite and fixed relationship between the amount of sludge which will accumulate in a septic tank and any given period of time. Normally one may expect a progressive accumulation during the colder months of the year, and in the spring and summer a period of violent bacterial activity coincident with rapid liquefaction of the sludge which has accumulated during the winter. A variety of factors may upset such a thing as constant accumulation of sludge, important among which are the composition of the sewage and the particu-

lar species of bacteria which it contains. In sewage from a combined system of sewers rain storms will bring down much grit and fine mineral matter which may form an inorganic mat over the sludge in the tank. Subsequent depositions of sludge then are forced to pass through the transitional stages leading to active bacterial liquefaction. If these conditions occur at abnormally frequent intervals, and if at the same time the bacterial flora contain a paucity of such species as are instrumental in the liquefaction of this sludge, the normal septic action may be retarded to a marked degree and the accumulation at the end of the year prove materially greater than in average years.

The authors comment upon the accumulation of a black deposit over the bottom of the sprinkling filter which received septic sewage, a condition not noted in the filter to which crude sewage was applied. A similar deposit was noted in the sprinkling filters at Columbus, but was not restricted to the filters which treated septic sewage, but rather to all of the filters. The conclusion arrived at there, as explaining the reason for this undesirable deposit, was that the underdrainage system was at fault. In filters built with false bottoms, and with drains laid with sufficiently steep slopes, such deposits as these should not occur at the bottom of such filters.

With reference to the bacterial efficiency of sprinkling filters, the authors conclude that the removals obtained at Boston were entirely inadequate. Due consideration does not seem to have been given to the question of growths within the filters, a feature commented upon by the authors, but not in connection with the question of bacterial efficiency. The sprinkling filter is a biological machine and as such is not to be expected to yield an effluent of high bacterial purity, so far as the numbers of bacteria are concerned. Removals of 85 per cent. of the bacteria in the crude sewage, as shown by the authors' experiments are, in the opinion of the writer, far from unsatisfactory for a number of conditions where fairly clear and wholly stable sewage effluents are required, but where effluents of high bacterial purity are not now demanded.

Mr. E. B. Whitman. — I have read the paper on the "Purification of Boston Sewage" with the greatest interest, as I believe the condition of the sewage treated at the sewage experiment station of the Massachusetts Institute of Technology will be quite similar to the condition of the sewage of Baltimore on reaching the disposal works at Back River, about five miles east of the city limits.

The sewage which was treated in Boston on one of the sprinkling filters, and termed "crude sewage," was not, strictly speaking, in a crude state. The "crude sewage" was screened through a half-inch screen, passed through a grit chamber and given some settlement in the distributing tank, to say nothing of the comminuting effect on the solid matter in passing through the pump. The effect of this preliminary treatment was to remove or comminute all the grosser solids, so that the solid matter reaching the sprinkling filter was in a very finely divided state.

The results obtained at Boston by Messrs. Winslow and Phelps confirm the writer's belief that septic action is not necessary previous to the treatment of sewage on sprinkling filters, provided the grosser solids which will clog the sprinkling devices and the filters themselves are removed before reaching the filters. There are several methods by which this removal of the grosser solids can be obtained, such as by means of a septic tank, by preliminary sedimentation for a few hours or by screening. The advantage of the septic tank over those other two methods lies in the fact that a large percentage of sludge which must be handled where sedimentation or screening is used is destroyed in the septic tank.

A recent decision in the United States Circuit Court of Appeals makes it impossible for the septic tank to be used without paying a royalty or having to fight an expensive lawsuit. This decision, however, does admit that sedimentation tanks can be used by the public in sewage treatment, and so brings sedimentation as a preliminary step to filtration prominently to the front among sanitary engineers.

This same decision also states that cesspools are not septic tanks, as there is not a continuous flow of sewage through these cesspools. It occurs to the writer that sedimentation tanks could be used to prepare the sewage for filtration, and these sedimentation tanks be so arranged as to discharge at intervals the accumulated sludge into secondary tanks, which might be termed "sludge digestion tanks." These would not be septic tanks, as the flow through them would be intermittent. There is no doubt about the sludge in cesspools being destroyed in a manner similar to sludge in septic tanks, and by such an arrangement as above suggested the combination of preliminary sedimentation tanks and sludge digestion tanks would accomplish the same results as the septic tanks. It might be possible that the hydrolyses of the solids in the sludge digestion tank would

be inhibited if the contents of this tank became too stale. This could be obviated by arranging the tanks in such a manner that the liquid over the sludge could be changed at more or less frequent intervals which experience might prove to be necessary.

The work of Messrs. Winslow and Phelps at Boston, as well as the writer's recent experience, would seem to demonstrate the possibility of such an arrangement as described above being used to advantage should the decision of the Circuit Court of Appeals be upheld in the Supreme Court and sanitary engineers be thereby shut out from the use of the septic tank or septic action as set forth in the patent papers and allowed by the judges of the Appellate Court.

Mr. W. J. Dibdin. — The very interesting and valuable series of experiments conducted by the authors dealt with an extremely dilute sewage such as is met with in England only under exceptional conditions, the strength being about one third of that of average London sewage. The present method of disposal is the same as formerly obtained for London, i. e., the dispersal of the sewage by dilution in a sufficient bulk of water. This, as at London, will be effective until the degree of maintained aëration is insufficient to allow the full activity of the aërobic organisms which render the sewage matters inoffensive. No nuisance will be observed until the maintained aëration falls below the safety point. In the meantime there is the risk of damage to oyster fisheries and, in regard to the possibility of danger to health through food supply or otherwise, the investigations recorded are not untimely.

The decision that septic and settlement tanks are unnecessary is to be welcomed, as it confirms the theory that aërobic action alone is necessary.

It is stated that the object of the experiments was to obtain a "stable effluent," and not one which complies more or less with arbitrary chemical factors. I would suggest that in testing for this quality the natural conditions should be maintained and the vessel left open to the air instead of being closed after the introduction of the methylene blue, so that the process of absorption of atmospheric oxygen, which takes place in a stream, might continue. Otherwise, if the vessel is closed the conditions of the test are artificial.

The percentage reduction of matters in solution is low for a final process, and the increase in the quantity of suspended matter is not a point for congratulation, although the change in the nature of the matters is of great importance. Since a

pound of living fish is preferable to a pound of fecal matter, the suggestion of the authors that " it is safer to discharge the sludge along with the effluent when it is possible to do so " is more reasonable than a non-biologist might think after perusing and considering only the chemical factors.

In connection with the advisability of treating the effluent with chloride of lime, the authors doubtless did not have in their minds the results of the experience obtained by myself in connection with the deodorization of the sewage of London from 1884 to 1890 pending the opening of the permanent purification works. When I received the order to deodorize the London sewage prior to its discharge into the Thames at Barking Creek and Crossness the only material available in any quantity was chloride of lime. The use of this material produced apparently good results at first, but when the effect of the chlorine disappeared the putrefaction of the sewage matters was objectionable in the highest degree, being worse than the nuisance from untreated sewage. I concluded that we must employ a deodorant which would supply oxygen without acting as a germicide. Permanganates were used, and in order to obtain a sufficient supply, I manufactured it by thousands of tons at Crossness on behalf of the Metropolitan Board of Works. The nuisance disappeared, in consequence of the oxidizing action of the permanganate, which also allowed the aërobic organisms to purify the river while precluding the putrefactive anaërobic action which followed the use of chloride of lime. Of course my action was resented by the bleach industry, and its foremost representatives argued that the oxidizing power of bleach was greater than that of permanganate for the money expended. The matter was referred to Sir Henry Roscoe, who confirmed my investigations after another £10 000 had been wasted on chloride of lime and the river had been made abominable once more by the use of that material.

There is a special point in connection with the Boston sewage which must not be overlooked. Since the dead matters of the sewage are turned into living matters by the use of the trickling filters and the sewage is thereby rendered self-purifying as long as sufficient aëration is maintained, the action of the chloride of lime will be to undo much of the work effected by the filters by turning the living into dead matter. The work thus undone will be repeated in the harbor, just as at present the original dead matters are rendered live and self-purifying. One wonders, therefore, if the chloride is to be used, what is the good of first treating the sewage on filters.

Of course where there are special pathological reasons for disinfection, and the bulk of sewage is small in comparison with the diluent water into which it is discharged, the use of chloride is comprehensible. In such a case, however, the chloride may be added to the sewage direct and the cost of filters saved, since the work of the filters will be carried out efficiently by the aërobic organisms in the diluent water when the effect of the chlorine has passed off.

Where the effluent is fairly free from " suspended " matters, it may be advisable to treat with chloride of lime, since the amount of living " animal " matters then killed will be small.

The following comparison of the results of the treatment of Boston sewage on trickling filters with those obtained by treating the sewage of High Wycombe in England on slate beds may be of interest. The accompanying tables show how closely the two sewages compare. The data for the High Wycombe results are from independent analyses made for the local authority of which I had no knowledge until I received a copy of the official report.

The chief difference between the two sewages is in the oxygen factor, presumably in consequence of the different methods of conducting the determinations. The results for the High Wycombe samples were obtained with the permanganate acting at 27 degrees cent. for 4 hours. I presume the Boston results were obtained in the manner described in the report of the Massachusetts investigations from 1888 to 1890, page 722, i. e., at boiling point for two minutes.* Otherwise the sewages are closely comparable if the albuminoid ammonia in the High Wycombe analysis is doubled to make it analogous to the nitrogen found by the Kjeldahl method as described on page 711 of the same report.

The effluents differs essentially in respect of suspended matter. The Boston effluent shows an increase from 9.4 to 9.7 grains per gallon, whereas the High Wycombe effluent shows a reduction from 10.2 to 3.6 grains. The reduction of organic nitrogen in the Boston effluent was 47 per cent., against a reduction of 46 per cent. of albuminoid ammonia for High Wycombe. The incubation test in both cases gave no fermentative change. The conclusion to which I am forced is that treatment of Boston sewage on slate beds *similar to those at High Wycombe* would give better results than those obtained by the use of trickling filters.

The number of acres of beds, 8 ft. deep, would be 23, against 50 required for trickling filters, as the number of gallons daily

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* Thirty minutes. — C.-E. A. W.

treated per cubic yard of bed was only 155 for trickling filters at Boston against 336 on slate beds at High Wycombe.

The experiments made by the authors of this paper and described by them in a previous report on brick beds bear little relation to slate beds. The use of small bricks 1½ by 4 by 12 in. would obviously give a different medium from thin slate layers, each slate varying from 1 to 2 sq. ft. super and averaging ¼ in. in thickness. The retention of solids, to take one point alone, is greater where the unit of surface is greater, as the solids tend to break away at the edges of the surfaces as the gelatinous organic condition progresses.

From results obtained at Devizes with a stronger sewage, I am inclined to think that the High Wycombe beds would treat a far larger volume of this dilute sewage daily and would still give satisfactory results. I have therefore suggested that one of the two beds at High Wycombe should be worked at six fillings daily, while the other remains at three. The estimate of work implied in this is really a low one in consequence of the manner in which the humus resulting from the sewage suspended matters is "worked over," to use the authors' phrase, and escapes from the slate layers and so obviates the risk of undue accumulation.

The deposit on the slate abounds in worms and the usual infusoria are plentiful. Although the bacteria are important it was in view of the higher organisms that I called the action "biological" originally in 1892. The term "bacteria beds," however, became popular. The higher organisms are employed to the maximum advantage in the thin layers of "living earth" obtaining on the slates and hence the results above described are explicable.

BOSTON AND HIGH WYCOMBE SEWAGES.
COMPARATIVE RESULTS.

Grains per Gallon.	Sewage.		Effluents.		Average London Sewage.
	Boston.	High Wycombe.	Boston.	High Wycombe.	
Total suspended matters,	9.4	10.22	9.7	3.64	30.6
Organic nitrogen (Kjeldahl) in solution,	0.4*	——	0.22*	——	——
Albuminoid NH_3,	——	0.150	——	0.082	0.386
Free NH_3,	0.98	1.050	0.73	1.070	2.995
Oxygen consumed in solution.	3.01‡	0.481†	1.75‡	0.342†	3.416†

* To be reduced to half these figures to equal albuminoid NH_3.
† At 4 hr. at 80° fahr.
‡ At boiling point for 30 min.

PERCENTAGE REDUCTION OF CONSTITUENTS IN EFFLUENTS.

	Boston Sewage.	High Wycombe Sewage treated on Slate Beds.
Organic nitrogen,	47.0%	......
Albuminoid NH_3,	......	46.0%
Oxygen consumed in solution,	42.0%	29.0%
Suspended solids,	Increased by 9.0%	Decreased by 62.0%
Incubation test,	No fermentative change	No fermentative change
Appearance,	Turbid	Cloudy.

NUMBER OF GALLONS TREATED PER CUBIC YARD OF BED DAILY.

Boston	High Wycombe.
155	336

NUMBER OF ACRES OF BEDS REQUIRED TO TREAT BOSTON SEWAGE BY TWO METHODS. 8 FT. DEEP.

As suggested.	On slate beds.
50	23

[Quantities have been expressed here by the British Imperial gallon. SECRETARY.]

PROF. C.-E. A. WINSLOW. — The authors of the paper on "The Purification of Boston Sewage" feel gratified that its discussion has elicited such important contributions to the question of sewage disposal. Nothing is of greater moment at the present time than to secure a general exchange of opinion between men of wide experience. A comparison of the opinions expressed makes it possible to determine pretty accurately what definite conclusions have been reached as a result of the work of the last two or three years and what questions are still in active dispute and awaiting a final settlement.

In the first place, there seems general agreement to-day that the anaërobic stage in sewage treatment is undesirable in so far as it affects the liquid sewage itself. The septic tank is a mechanism for removing solids by sedimentation and liquefying as much as possible of the sludge removed. Its action on the liquid should be minimized as far as possible. This means, of course, that septic tanks should be designed to secure the maximum removal of suspended solids by sedimentation with the least possible prolongation of the period of treatment. The second point, which may be regarded as settled, is the contention that the operation of the trickling filter should be made as uniform as possible. A bacterial bed is a biological mechanism, the operation of which should be made as constant and even as possible. Of course, intermittent dosing at intervals of a few

minutes, does not essentially alter the conditions in the bed, but it seems now accepted that long resting periods for trickling beds are to be deprecated.

On the other hand, several of the questions raised in the paper under discussion are still open ones. The first and most important point, perhaps, concerns the possibility of treating crude sewage in biological beds, wholly or mainly aërobic in nature, without preliminary removal of solids. The position of the authors is that this is at times good policy. Mr. Dibdin and Professor Kinnicutt appear to hold the same view, while Messrs. Fuller and Johnson dissent from it. It is undoubtedly true, as Mr. Fuller says, that if crude sewage can be purified at a given rate, septic sewage may probably be purified at a somewhat higher rate. It is true, too, as Mr. Johnson points out, that if crude sewage can be treated on a bed built of material of a certain size, septic sewage can almost certainly be treated on a bed of finer material. In our particular case, however, it was evident that crude sewage could be treated at a rate of 2 000 000 gal. per acre per day on a bed of 1½-inch to 2-inch stone with success. Mr. Whitman's criticism of the character of the sewage applied is apparently made under a misapprehension. The material settled out in the distributing tank was never removed and all passed eventually to the filters. The half-inch screen and grit chamber removed only the heavy, inorganic material, as shown by the fact that it was spread out on the experiment station grounds in the midst of a city without production of odor. Such material as this will, of course, be removed in any practical process, as it would be the worst economy to allow a septic tank to sludge up with street washing and grit.

We are, of course, very far from wishing to extend our conclusion to all other cases, or to many other cases. There are two main objects to be attained in sewage purification,— the removal of suspended solids and the oxidation of organic matter. Solids may be removed before treatment in filters, or after treatment in filters, or they may be allowed to accumulate in the filter beds. Experience shows that the last policy is rarely economical. Which of the first two shall be chosen depends on various peculiarities of the individual case. Where trickling beds are used, however, if an effluent free from suspended solids is desired, some final sedimentation will generally be required. If this is the case, it must often be of advantage to dispense with the preliminary sedimentation, purifying the crude sewage on trickling beds and doing all the necessary removal of solids at the end of

the process. In any given case this may or may not be cheaper than preliminary septic treatment combined with subsequent sedimentation. Our own contention is that it is possible to purify crude sewage on trickling beds, and that under certain circumstances it is better practice to do so. It seems to be so in the Boston case.

A second question of considerable interest is raised by Mr. Dibdin's comparison between the trickling bed and the contact bed. It is interesting to notice that the general effect of the two processes is so nearly the same. The incubation test, however, cannot of course be compared, since, as Mr. Dibdin points out, the test used by us was a very severe one. The main difference, aside from the high rate obtained by the use of contact beds at High Wycombe, lies in the fact that the contact beds removed two thirds of the suspended solids present, while our trickling beds slightly increased the suspended matter. This, in my judgment, indicates a distinct advantage for the trickling bed. Any biological bed which removes suspended solids must store a considerable portion of them. Storage of suspended solids means limitation of the life of the bed and its ultimate renewal. Of course Mr. Dibdin's plate beds, with their large capacity, minimize this danger as far as possible, but the fact that the trickling bed does not store suspended solids at all seems to promise an almost indefinite extension of its activity. In my own opinion, some anaërobic process furnishes the best means of removing solid material if it must be removed, and this can, I think, be done with greatest economy apart from the purification process itself, either preceding or following it.

The third point upon which we are not all in agreement is the question of the efficiency of trickling beds with regard to bacterial purification. There is no doubt of the fact that septic tanks and trickling beds ordinarily effect, as Mr. Fuller says, a purification of 65 to 70 per cent. on the original bacteria entering the system. It is also, no doubt, true that disease germs do not grow in trickling beds. Neither probably do colon bacilli, but colon bacilli persist, according to authentic results, at many plants, in about the same proportion as the other bacteria applied and appear in the effluent in numbers perhaps a quarter or a third as great as those in which they occur in the sewage. If this is the case, we have no right to assume that the removal of disease germs is any better; and it certainly cannot be considered that bacterial purification of 75 per cent. is of any particular sanitary consequence. Of course, in many cases bacterial purifi-

cation of sewage is entirely unnecessary, but I am strongly of the opinion that, where it is necessary, septic tanks, contact beds, and trickling filters cannot be relied upon.

Where special bacterial purification is desired, the experience of the last two years has clearly shown that it can be accomplished by disinfection with some form of chlorine. No other disinfectant appears to approach chlorine in economy and efficiency. There still seems, however, to be considerable difference of opinion in regard to the exact cost of this procedure. In Mr. Pratt's very interesting account of the disinfection of the sewage at Camp Perry, Ohio, he gives the cost of the process as $7.50 per million gallons. Our estimates were $1.50 for Boston trickling effluent. This is fairly typical of the differences which appear between different estimates in regard to this process. In the particular case in question the high cost at Camp Perry appears to be due to two things. In the first place, the chemical was applied at the rates of 7.5 parts of available chlorine per million. In our own case we have found 5 parts amply sufficient to disinfect trickling effluent, and sand effluent can be treated with a much smaller amount. In the second place, the price quoted by Mr. Pratt is 4 cents a pound. This was presumably due to peculiar local conditions. The market price of this product is quoted at about 1¼ cents per pound, and with the addition of freight charges it has been obtained in small quantities below 2 cts. in recent experiments at Red Bank, N. J., and Baltimore, Md.

We are in entire agreement with Mr. Dibdin's contention that the disinfection of putrescible sewage is generally an undesirable thing. His experiments on the treatment of the Thames water with chloride of lime taught on a large scale the lesson that putrescible matter must eventually putrefy, and that to delay the process by using a disinfectant only makes the ultimate event worse. Our point of view is that when stability has been attained, that is, when there is no longer any danger of putrescibility and no longer any need for oxidizing bacteria, it is safe and proper to remove the disease germs by disinfection. Organic stability must be attained as the primary end and by bacterial means . After that is done there can be no harm in removing the germs from an effluent containing only stable humus-like solids. The disinfectant is, of course, used up in the process, so that no damage will be done to the living organisms in the water into which the end product is discharged. We entirely agree with Mr. Dibdin and with Mr. Baker that the disinfection of crude

sewage is only justifiable under exceptional conditions of great dilution.

In closing this discussion I want to take the opportunity of expressing again the desire of the staff of the Sanitary Research Laboratory and Sewage Experiment Station of the Institute of Technology to be of assistance in the study of the scientific and engineering problems which come within its scope. We are ready at any time to attack, as far as we are able, problems of fundamental and general interest which sewage engineers care to submit to us. That is one of the objects for which the station exists, and we shall always be glad to pursue such investigations as far as time permits.

DISCUSSION ON MR. HARPER'S PAPER, THE SAN FRANCISCO EARTHQUAKE OF APRIL 18, 1906.

(Vol. XL, page 87, February, 1908.)

MR. LUIS MATAMOROS, San José, Costa Rica, April 1, 1908. — In Mr. Harper's paper on the San Francisco earthquake I have read the only clear conception about the direction of the seismic movements which accords with my own studies of the theory of the cause of earthquakes, published a few years ago, at the time of the destruction of the city of St. Pierre (Martinique).

On or about those days, June, 1902, the *Scientific American* in New York, and *Nature* in Paris, expatiated upon some new theories about earthquakes which I esteemed wrong, and to prove such an assertion published in *Boletin de las Escuelas*, San José de Costa Rica, on the 12th of July, 1902, my own conclusions, after many years of experience and observation. In that paper I tried to prove:

First. That the figure of the earth is not a constant one.

Second. That the continual changing of form generates a great amount of heat and electricity.

Third. That this heat is the " internal heat " of the earth, and not the " central fire," as was thought before.

Fourth. That the great amount of electricity developed by the friction of the molecules of the earth in changing its form accumulates in certain points of the globe, and when its potentiality becomes high is discharged through weaker points, causing the earthquake.

Fifth. That this theory is the only one which explains clearly its observed effects on monuments and buildings, and also explains the phenomena of the zones into which the earth is divided, a fact in accord with experience and observations.

To prove that the figure of the earth is not a constant one is very easy. Mr. Mansfield Merriman, in his splendid work on the " Figure of the Earth," Chapter V, says: " The word *geoid* is used to designate the actual figure of the surface of the waters of the earth. The sphere, the spheroid, the ellipsoid, the ovaloid and many other geometrical figures may be, to a less or greater degree, sufficient practical approximations to the geoidal or earthlike shape, yet no such assumed form can be found to represent it with precision. The geoid, then, is an irregular

figure peculiar to our planet,—so irregular, indeed, that some have irreverently likened it unto a potato,—and yet a figure whose form may be said to be subject to fixed physical laws if only the fundamental ideas implied in the name be first clearly and mathematically defined." In the last paragraph of the book we read, " In conclusion it will be well to note that our geoid is not a fixed and constant figure."

Mr. Harper is not mistaken in his apprehension of the movements as he explains them. His judgment is also correct when he apprehends the direction of the movements and the time in which they occur. He has nothing to do but to consider the least-work of an electric spark crossing the mass of the earth. When the sparks cross the space it is well known that the figure of the path for least-work is a "Cartesian folium": practically you call this figure a zigzag, because we cannot see the curve, but it is very easy to explain it as a logical fact.

If we imagine an electric spark in the air in an indefinite direction, when it runs the pressure of the air becomes higher, resisting the motion. The spark rarefying the air reaches a point where the air's resistance is greater than its power, and the spark, then, comes back traversing with much less effort than at the beginning the air already rarefied, continuing on this back and forth movement until its energy is consumed, making practically a zigzag.

The mechanical effects of this kind of movement are the same as a pair of forces acting in contrary directions; coupling forces acting upon a body give a movement of rotation around the center of the body, as we feel at the instant of the earthquake, which Mr. Harper has confirmed by his own observation in the *cemeteries*.

In my paper I said: " Yet we have vestiges in the *cemetery* of this city and on the square columns of the barracks of the city of Alajuela which show the phenomena of the rotation produced by earthquakes."

I will end here, but not before offering my compliments to Mr. Harper for his very valuable work.

Association of Engineering Societies.

Vol. XL. JANUARY, 1908. No. 1.

PROCEEDINGS.

Montana Society of Engineers.

Butte, Mont., December 14, 1907. — The meeting of the Society for December was held at 225 North Main Street, Room No. 16, at the usual time. Quorum present. Ex-President C. W. Goodale presided. The minutes of the last meeting were read and approved. The application for membership of Edward D. Kinney was read, approved and the ballot ordered in the regular manner. The Secretary read an outline of the program of the Annual Meeting, also a letter asking the Society to take some action towards the suspension of Annual Assessment work on Mining Claims for 1907. After discussion it was decided that the time was too short to consult Montana's Congressmen in the matter. The Secretary reported the death of Mr. Chas. A. Molson, a member of the Society, and Messrs. Dunshee, Moore and Adams were chosen as a committee to draft resolutions.

The committee appointed at the last meeting reported the following amendment to the By-Laws, to be voted on at the next meeting.

Section 8, Article V. In case of failure on the part of any member, for three years to pay the prescribed annual dues, or any special assessments that may have been levied, after due notice of such delinquency shall have been given by the Secretary, the Society may, at any regular meeting, by a two-thirds vote of the active and associate members present and voting, declare such delinquent member indefinitely suspended or expelled from the Society; provided that the dues and assessments of any member may, for cause shown, be remitted by an affirmative two-thirds vote of the active and associate members at a regular meeting.

Following is an alternative amendment to Section 8, Article V: In case of failure on the part of any member for two years to pay the prescribed annual dues or any special assessments that may have been levied, after due notice shall have been given by the Secretary, the name of such delinquent member shall be dropped from the list of members of the Society, and if such delinquency shall continue for three years, such delinquent member shall forfeit all rights to membership and shall not be reinstated without being re-elected and paying the same initiation fee and annual dues and assessments demanded from other candidates for admission.

Respectfully submitted,

John D. Pope.

Mr. C. W. Goodale gave an interesting talk about several irrigation projects in northern Montana, which he had visited during the past season.

Adjournment.

Clinton H. Moore, *Secretary.*

Technical Society of the Pacific Coast.

San Francisco, December 13, 1907. — A meeting of the Society was held on Friday, December 13.

The meeting was called to order by Past President Marsden Manson.

The Secretary read the minutes of the last regular meeting, which was held on December 6, in Coopers Medical Hall. At this meeting a reception was held in honor of Past President George W. Dickie, who had been absent from the state for about eighteen months and who returned to reëstablish his home in California. Mr. Dickie addressed the members present and referred to the pleasant relations existing for many years between the Technical Society and the older members, expressing the hope that these relations, which had been severed by the great catastrophe, may be renewed within the immediate future.

Mr. Axel Welin, member of the Naval Institute of Architects, delivered a lecture on the subject of "Appliances for Manipulating Life-Boats on Sea-going Vessels." The lecturer described in detail the design of a davit for sea-going vessels which had been applied successfully by the great traffic companies of the Atlantic.

The minutes of this meeting were approved.

The following Nominating Committee was appointed to select a ticket of officers for the ensuing year: Marsden Manson, Jas. C. Bennett, Loren E. Hunt, John B. Leonard, Frank P. Medina.

A ticket is to be prepared by this committee, which will be voted in time to announce the result at the annual meeting to be held in the middle of January, 1908.

The Board of Directors discussed the advisability of holding the regular meetings at some restaurant, preceding the ordinary course of business by an informal dinner. The difficulty of getting the scattered members together in San Francisco at the present time is so great that unless the meeting be combined with the usual evening meal it will not be well attended.

The Secretary was instructed to make the necessary inquiries and arrangements so that the annual meeting, which is to be held in the middle of January, may be held at one of the down-town restaurants.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Association of Engineering Societies.

Vol. XL. FEBRUARY, 1908. No. 2.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, December 4, 1907. — The 642d meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, December 4, 1907, at 8.15 o'clock. President Fish presided. Nineteen members were present.

The minutes of the 641st meeting were read and approved. The minutes of the 431st and of the 432d meetings of the Executive Committee were read.

The following applications were read: Hendrich, Walter F. (member); Quebbeman, Edward (associate member).

The Secretary read a letter from Mr. W. R. Bascome announcing the donation to the Club of the revised drawings and specifications for the Manhattan Bridge of New York City. The Secretary was instructed to make due acknowledgment of the same.

Mr. E. R. Fish read the report of the Executive Committee for the year 1907. On motion duly seconded it was voted that the report be received and filed.

Mr. A. S. Langsdorf presented a report of the Secretary's office for 1907. It was voted that the report be received and filed.

The report of the Librarian for 1907 was presented by Mr. A. S. Langsdorf. It was voted that the report be received and that it be referred to the incoming Executive Committee for consideration.

Mr. E. E. Wall presented the Treasurer's report for 1907. It was voted that the report be received and referred to the Executive Committee for action.

The report of the Entertainment Committee for the year 1907 was presented by Mr. A. S. Langsdorf. It was voted that the report be received and filed.

The report of the Board of Managers of the Association of Engineering Societies was read by Mr. A. P. Greensfelder. It was voted that the report be received and filed.

Inasmuch as the membership of the Club is now in excess of two hundred and fifty, the Club is entitled to three representatives on the Board of Managers. The Nominating Committee, through Mr. E. B. Fay, therefore presented a supplementary report, nominating Mr. J. T. Dodds as the third member of the Board of Managers for the year 1908. The following two members had been nominated for the Board in the original report of the Nominating Committee: Mr. R. L. Murphy and Mr. O. W. Childs.

The President called for additional nominations for officers for the year 1908, but none were made.

Mr. William H. Bryan announced the election of Mr. M. L. Holman as president of the American Society of Mechanical Engineers. After some discussion it was moved to tender a complimentary dinner to Mr. Holman and to refer the details to the incoming Executive Committee. Motion carried.

It was moved and seconded to hold the usual annual dinner, all details to be arranged by the present Executive Committee. Motion carried.

Adjourned.

A. S. Langsdorf, *Secretary.*

Annual Dinner.

St. Louis, December 18, 1907. — The 643d meeting of the Engineers' Club of St. Louis was held at the Mercantile Club, 7th and Locust streets, on Wednesday evening, December 18, 1907, at 7.30 o'clock, President Fish presiding. The total attendance was 46, of which 40 were members and 6 were guests. Among the latter were Prof. Benjamin F. Groat of the University of Minnesota, Prof. C. M. Woodward of Washington University, and Mr. Daniel N. Kirby of St. Louis.

The results of the letter ballot for the election of officers for 1908 were announced as follows:

President — W. G. Brenneke.
Vice-President — E. E. Wall.
Secretary and Librarian — A. S. Langsdorf.
Treasurer — O. F. Harting.
Directors — J. F. Hinckley, W. V. N. Powelson.
Board of Managers — R. L. Murphy, O. W. Childs, J. T. Dodds.

After a course dinner the following toasts were responded to: Address of the retiring president, "Our Sphere of Influence," E. R. Fish; "An Engineering Problem," Prof. B. F. Groat; "What is there in It for Us?" E. E. Wall; "A Legal Aspect of Engineering Responsibility," D. N. Kirby; "Elasticity as a Desirable Quantity of Engineering Specifications," W. Robbins.

At the conclusion of the regular addresses, Professor Woodward was called on for a few remarks and responded informally.

The meeting adjourned at 11 p.m.

A. S. Langsdorf, *Secretary.*

St. Louis, January 15, 1908. — The 644th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, January 15, 1908, at 8.15 o'clock, President Brenneke in the chair. There were present 41 members and 15 visitors.

The minutes of the 642d and 643d meetings were read and approved.

The minutes of the 433d and 434th meetings of the Executive Committee were read.

The following were elected: Walter F. Hendrich (member); Edward Quebbeman (associate member).

Applications were read from Donald G. Scott (member), Benjamin McKeen (member), Walter E. Bryan (junior).

The Secretary announced the appointment of the Entertainment and Membership committees as follows:

Entertainment Committee: C. A. Bulkeley, chairman; A. I. Jacobs, W. H. Hand, R. K. Einstein, R. H. Phillips.

Membership Committee: A. C. Cunningham, chairman; R. L. Murphy, R. Morey.

Mr. H. Struckmann then presented the paper of the evening on "The Development of the Portland Cement Industry in Europe and the United States." The history of the manufacture of cement was briefly reviewed, and the remarkable growth of the industry shown by comparative figures since the year 1890. Lantern slides were used freely to show various processes of manufacture in the United States and abroad, and samples of the material were shown in all stages, from the raw state to the finished product.

At the conclusion of the address a lively discussion was participated in by a large number of those present.

Adjourned.

A. S. LANGSDORF, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, JANUARY 22, 1908. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock P.M., President E. W. Howe in the chair; one hundred and fifteen members and visitors present.

The record of the last meeting was read and approved.

Messrs. William H. Balch, Thomas F. Campbell, Albion M. Deane, Walter J. Grady, Angus B. MacMillan and Arthur D. Weston were elected members of the Society.

On motion of Mr. A. H. French, the President was requested to appoint a committee of three to retire and report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The President named as that committee, Messrs. A. H. French, R. A. Hale and J. A. Gould. This committee reported the following names for members of the nominating committee, Arthur L. Plimpton, Leonard C. Wason, John L. Howard, Henry B. Wood and Charles W. Sherman. On motion of Mr. F. P. Stearns, the report was accepted and the members named were chosen as the nominating committee.

On motion of Mr. FitzGerald, it was voted to hold the customary annual dinner and that the usual committee (Mr. Henry Manley) be appointed to make the necessary arrangements.

The literary exercises of the evening consisted of a description of the Double Track Railroad Tunnel under the Detroit River at Detroit. Mr. H. A. Carson gave an historical account of various methods which had been used for the construction of similar tunnels and described plans which had been suggested for the building of this tunnel, illustrating his remarks by the aid of lantern slides. Mr. William J. Wilgus, of New York, Chairman of the Advisory Board of Engineers, was then introduced and gave a most

interesting account of the plan finally adopted for the Detroit Tunnel and of the work of construction now in progress. A large number of views were thrown on the screen showing various stages of the work.

On motion of Mr. F. P. Stearns, the thanks of the Society were voted to Mr. Wilgus for his kindness.

Adjourned.

S. E. Tinkham, *Secretary.*

Montana Society of Engineers.

Twenty-first Annual Meeting Held at Bozeman, Mont., January 9, 10, 11, 1908.

Thursday. — The visiting members of the Society were met on the arrival of the afternoon trains by the entertainment committees, composed of the leading citizens of Bozeman, escorted to the Bozeman Hotel, where, after a brief rest, they were shown about town and afforded an opportunity to note the general prosperity manifestly evident on every hand. During the evening they were the guests of the Gallatin Valley Commercial Club and made to feel quite at ease through the generous hospitality of the numerous membership of that organization. Many old-time friendships were revived from acquaintances made, and too soon the hour for "dry" town folks was at hand.

Friday. — Promptly at the hour selected by the committee in charge of the day's program the members became the guests of the Bozeman Electric Railway Company, and were taken to the grounds of the Montana State College. A short time was devoted to the inspection of one of the college buildings and its magnificent equipment, whence, under the guidance of the resident members of the Society who are instructors in the college, the visitors were ushered into the presence of the students and faculty in the college auditorium assembled. A very cordial address of welcome by President Hamilton was followed by short talks on the part of prominent engineers. The college band delighted all listeners by their proficiency, and after a short time devoted to several class rooms and library, the real thing was placed before the visitors — something they wanted and could digest — in the shape of a superb luncheon prepared by the culinary artist students of the Domestic Science Department of the college. Here the Entertainment Committee struck a snag — the guests would not offer to proceed, and had they not exhausted the larder it is ikely that the engineers' meeting would have ended without another session. Appreciative words were said, gray-haired orphans called for "pie," and the swinging doors of the banquet hall creaked farewell. The remainder of the day was consumed in visiting the various departments of the college, furnishing advice to each other and the students, learning many new things not found in old books, and taking a special pride in this magnificent state school. Relays of instructors acted as guides, flocks and herds were at their best, and the balmy air brought comfort to every visitor. The evening entertainment was furnished by the Bouffon Club of the city and was of a social nature, made successful by the presence of Bozeman's fair dames and daughters.

Saturday. — The business session was called to order in the Agricultural Annex of the Gallatin Valley Commercial Club at 10 A.M., President E. C. Kinney presiding. Twenty-two members present. Minutes of last meeting read and approved. The Secretary read the applications for membership in the Society of Messrs. Tannatt, Dearborn, Locke, Kneale, Flaherty, Sacket and Davis, and after approval the necessary ballots were ordered. Edward Daniel Kinney, son of President Edward C. Kinney, was elected to membership by a unanimous vote. The Secretary presented the ballots of the officers elected; tellers counted the same and reported 43 ballots, all " yes." President Kinney declared the following officers elected for 1908: President, Archer E. Wheeler; First Vice-President, Charles H. Bowman; Second Vice-President, Frank M. Smith; Secretary and Librarian, Clinton H. Moore; Treasurer and Member of the Board of Managers of the Association of Engineering Societies, Samuel Barker, Jr.; Trustee for three years, John C. Adams. In the absence of President Wheeler, Vice-President Bowman acted in his stead. The annual reports of the Secretary and Treasurer were now read and referred to the Trustees. The Committee on Resolutions on the death of the late Charles A. Molson presented the following, which were read by the Secretary:

Whereas, God in his providence has removed from our midst Charles A. Molson, a member of this Society, now, therefore, be it

Resolved: That in the death of Charles A. Molson this Society has suffered an irreparable loss. His sterling qualities of head and heart were well known to his many friends, and his conscientious discharge of every duty intrusted to him is testified to by his employers as well as by those associated with him in the management and development of mines.

In 1888, and for many years following, he was actively engaged in the management of Montana mining properties. On leaving Montana he established his headquarters in Salt Lake City, and up to the time of his death he followed his chosen work of examining and reporting upon mining properties. He was known from Mexico to the British possessions as a thorough, honest and painstaking engineer.

Resolved: That this Society shall express, by these resolutions, its sincere sorrow on the death of Mr. Molson, and these resolutions shall be spread upon the minutes of the Society and a copy forwarded to his bereaved family.

B. S. DUNSHEE,
J. C. ADAMS,
C. H. MOORE,
Committee Montana Society of Engineers.

The amendment to the by-laws heretofore proposed was considered, and on motion rejected. The resignation of Howard D. McLeod and the request of Ambrose E. Ring for a transfer to the list of corresponding members received proper consideration. On motion, the Secretary was instructed to solicit the good offices of the Montana Congressional delegation in behalf of the bill granting aid to land grant colleges for engineering research, now pending in Congress. Several letters of regret from absent members were read, reminding many of early days. The Secretary then outlined the program for the afternoon and a recess was taken till 2 P.M. The afternoon session began at the hour named, Vice-President Bowman in the chair. A telegram from President Wheeler was read, regretting his unavoidable absence. The address of the retiring president, Edward C. Kinney, received the unstinted approval of a large and appre-

ciative audience. This address was followed by an account of the progress of the work of the Reclamation Service in Montana by H. N. Savage, engineer in charge. A paper by Mr. Joseph H. Harper on the subject "The San Francisco Earthquake," created much interest among its listeners, and another essay entitled "The Development of the West Coast of South America," by Mr. F. W. Blackford, received many favorable comments. A short talk on a "Placer Mining Fraud" in Wyoming, by Mr. E. W. King, completed the literary work of the day. The question of a midsummer meeting was next considered, and after considerable favorable discussion the trustees were instructed to try to hold a summer meeting during the current year. The usual banquet ended the actual work of the annual session.

CLINTON H. MOORE, *Secretary.*

Technical Society of the Pacific Coast.

SAN FRANCISCO, FEBRUARY 15, 1908. — Annual meeting of the Technical Society of the Pacific Coast, held January 24, 1908. The following officers were duly elected to serve during the ensuing year:

President — George W. Dickie, Mechanical Engineer, San Mateo, Cal.

Vice-President — H. D. Connick, Assistant City Engineer, City Hall, San Francisco, Cal.

Secretary — Otto von Geldern, Consulting Civil Engineer, 1978 Broadway, San Francisco, Cal.

Treasurer — E. T. Schild, Manufacturer, 1908 Broadway, San Francisco, Cal.

Directors — Hermann Barth, Architect, 641 Mission St., San Francisco; Edw. F. Haas, Civil Engineer, 628 Montgomery St., San Francisco; L. A. Hicks, Civil Engineer, Humboldt Bank Building, San Francisco; Loren E. Hunt, Civil Engineer, University of California, Berkeley; C. B. Wing, Professor of Engineering, Leland Stanford, Jr., University, Palo Alto, Cal.

On the Board of Managers of the Association of Engineering Societies, the President, Mr. George W. Dickie, and the Secretary, Mr. Otto von Geldern, were chosen to act as heretofore customary.

A paper was read by Mr. George W. Dickie, the President of the Society, entitled "Mechanical Engineering as Practiced on the Atlantic and Pacific Coasts," which was ordered to be sent to the JOURNAL for publication.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Detroit Engineering Society.

DETROIT, MICH., JANUARY 24, 1908. — Meeting called to order at 8.10 P.M., President E. S. Wheeler presiding.

Minutes of the regular meeting of December 20 read and approved.

The following candidates were elected to membership: Hugo Arnold,

Fred Lockwood, Sherman Moore, Thomas Russell, Melvin A. Gilbert, Otto S. Zelner.

The paper of the evening was presented by Francis C. Shenehon on " The Right of Way of the Great Lakes."

Discussion followed by the following: A. Geo. Mattsson, on " The Power of Boats on the Great Lakes" ; C. Y. Dixon, on " The Detroit River" ; Col. Chas. E. L. B. Davis, on " The Regulation of Navigation in the Various Channels" ; Edward Molitor, on " Cost and Preparing Lake Charts" ; Geo. H. Fenkell, on " Distribution of Water for Drinking Purposes" ; F. G. Ray, on " Unknown Shoals and Hidden Obstructions."

Moved by B. E. Parks, seconded by A. Geo. Mattsson, that the Society tender Col. Chas. E. L. B. Davis a vote of thanks for the valuable collection of books presented to the Society. Carried.

Members present, fifty-one.

Moved that we adjourn. Carried.

BAMLET KENT, *Secretary.*

Louisiana Engineering Society.

Synopsis of Proceedings of the Last Six Months.

DURING the months of July and August no meetings were held, the Society following the usual custom of adjourning for these two months.

The first regular meeting after this summer adjournment was held on September 9, 1907, which proved to be the last one held in the old quarters of the Society in the Tulane-Newcomb Building. Mr. G. W. Lawes read an interesting paper entitled, " Subaqueous Phenomena at the Mouth of the Mississippi." An informal discussion followed, which brought out very interesting facts.

The meeting of October 14 was held at the new headquarters of the Society in Gibson Hall, Tulane University. The Society was welcomed to its new home by Prof. W. H. P. Creighton, who spoke of the advantages resulting from the union of the two forces and from the merging of the two libraries of Tulane University and the Louisiana Engineering Society, and expressed the hope that both would see lots of good resulting from the closer union. Mr. G. W. Lawes replied with a word of appreciation, a bit of history, a bright outlook for the future and a prediction of the good results in store for the Society and for Tulane University. Major B. M. Harrod, by request, spoke upon the recent change, outlined the growth of the idea and expressed his entire satisfaction with the work accomplished. The meeting then adjourned to visit the Tilton Memorial Library of the University, in which the library of the Society has been placed.

At the meeting of November 11, Mr. G. W. Lawes read a short paper on " High Buildings in New Orleans," which paper he said was written to invite discussion on so important a subject. A discussion fully entered into by all the members followed.

The meeting of December 12 was well attended. Mr. M. P. Robertson read a most interesting and entertaining paper entitled " Some His-

torical Facts as to the Discovery and Use of the Magnetic Needle and Some Facts from the Author's Experience with the Compass and Jacob's Staff in Land Surveying in Louisiana." Nominations of officers to serve for 1908 were had as follows: For President, C. W. Wood and M. P. Robertson; for Vice-President, J. T. Eastwood and John Riess; for Secretary, A. C. Duval and L. C. Datz; for Treasurer, J. C. Haugh and A. L. Black; for Director, J. W. Armstrong and Marcel Garsaud; for Member of Board of Managers of the Association of Engineering Societies, G. W. Lawes. It was then decided to have the annual meeting followed by the annual banquet.

On January 11, 1908, this meeting was held at the New Denechaud Hotel. The annual reports of the Board of Direction, Secretary, Treasurer and Library Committee were read. A membership of 107 and a balance cash on hand of $370.52 were shown. The ballots for the election of officers were counted and the following were declared elected: C. W. Wood, President; J. T. Eastwood, Vice-President; L. C. Datz, Secretary; J. C. Haugh, Treasurer; Marcel Garsaud, Director; G. W. Lawes, Member Board of Managers of the Association of Engineering Societies.

Mr. Wood, in a few well-chosen words, thanked the Society for the honor. The newly elected officers were then installed.

Mr. Lawes, the retiring President, read his annual address, after which the meeting adjourned to the banquet hall, Mr. H. J. Malochee acted as toastmaster, and an evening of good fellowship and interesting talks prevailed.

Association
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Engineering Societies.

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PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, February 5, 1908. — The 645th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, February 5, 1908, at 8.30 o'clock. President Brenneke presided. Forty-nine members and thirteen visitors were present.

The minutes of the 644th meeting were read and approved, and the minutes of the 437th meeting of the Executive Committee were read.

Applications were presented from the following: Albert Belding Gaines, Jr. (member), Walter Leo Hempelmann (member), Frank E. Washburn (member), William J. McCully (associate member).

The following were elected: Benjamin McKeen (member), Donald G. Scott (member), Walter E. Bryan (junior).

The Secretary read an invitation received from the University of Illinois to send a representative to the installation of Prof. W. F. M. Goss as Dean of the College of Engineering on Wednesday, February 5. It was announced that Mr. O. Stephensen, a member of the Club now resident in Urbana, Ill., had been asked to represent the Club at this function.

The paper of the evening, on "Some of the Problems Involved in the Construction of a Deep Waterway from the Lakes to the Gulf," was then read by Col. J. A. Ockerson. The paper discussed the problems to be solved in constructing the waterway in the several reaches of the river, namely, from Chicago through the Illinois River to Grafton; from Grafton to St. Louis; from St. Louis to Cairo; and from Cairo to the Gulf. Lantern slides were freely used to illustrate the different points presented.

An interesting discussion at the close of the reading of the paper was participated in by Mr. W. K. Kavanaugh, of the Inland Waterways Commission; Mr. James E. Smith, President of the Business Men's League; Mr. Edward Devoy, President of the Merchants' Exchange; Mr. W. F. Saunders, Secretary of the Business Men's League; and by Colonel Ockerson, Mr. Robert Moore and Mr. Julius Pitzman.

Adjournment.

A. S. Langsdorf, *Secretary.*

St. Louis, February 19, 1908. — The 646th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, February 19, at 8.30 o'clock. President Brenneke presided. There were present twelve members and seven visitors.

The minutes of the 645th meeting were read and approved.

The Secretary read a letter from Miss Mary J. Klem, Librarian of the Academy of Science, requesting that a representative of the Engineers' Club be appointed to attend a conference to discuss ways and means for increasing the efficiency and usefulness of the various technical libraries of the city. It was announced that the Librarian of the Club had been appointed by the chairman as a representative at this conference.

The following applications were presented: Rolla Copley Bulkeley (member), Fred Lyle Bunton (member), Robert Hasbrouch Wyld (member), Harold Cantwell Burgess (junior).

The following were elected: Albert Belding Gaines, Jr. (member), Walter Leo Hempelmann (member), Frank E. Washburn (member).

There being no further business, the paper of the evening on the Photometry of Electric Lamps was presented by Mr. George W. Lamke. There were described in detail the various methods used for the determination of horizontal candle-power, mean horizontal candle-power, mean spherical candle-power and mean hemispherical candle-power; also descriptions of the apparatus used in these determinations, illustrated by lantern slides, as well as of the various standards of light adopted as to basis of comparison.

At the conclusion of the reading of the paper an interesting discussion was participated in by Dr. Hyde, of the United States Bureau of Standards, and by Mr. Rollins, of the Electrical Testing Laboratory of New York City, both of whom are specialists in electric lamp photometry. Mr. A. S. Langsdorf also participated in the discussion.

Adjourned.

A. S. Langsdorf, *Secretary.*

The Civil Engineers' Club of Cleveland.

Regular Meeting, February 11, 1908, at the Club Rooms, called to order by President Wright at 8 p.m. Present, 60 members and visitors.

Minutes of preceding meeting read and approved.

The tellers, Messrs. Horner and E. B. Thomas, reported the election to Active Membership of Frank Van McMullin.

The application of William Edmund Simpson, approved by the Executive Board, was read.

The Nominating Committee presented the following nominations for officers for the ensuing year:

President — Willard Beahan.
Vice-President — Robert Hoffmann.
Secretary — J. C. Beardsley.
Treasurer — J. H. Fox.
Librarian — George H. Tinker.
Directors — H. E. Baldwin, W. O. Henderer.

On motion of Mr. Lane, the report of the committee was accepted.

Amendments to the constitution, submitted by the Executive Board, were read by the Secretary. After some discussion by Messrs. Ritchie, Palmer and Green, on motion of Mr. B. L. Green, the Secretary

was directed to have the proposed amendments printed and mailed to the members for discussion at the April meeting of the Club.

Mr. W. J. Springborn, President Board of Public Service, gave a "Description of the Cleveland Garbage Disposal Plant and Methods in Use in Operation," illustrated by many lantern slides. Discussion was taken part in by Messrs. Lane, Rowe, Prentiss, Wenzell and others.

On motion of Mr. Osborn, a vote of thanks was tendered Mr. Springborn.

Adjourned.

J. C. Beardsley, *Secretary.*

Annual Meeting, March 10, 1908, at the Cleveland Athletic Club, called to order by President Wright at about 9.30 p.m. Present, 76 members and 32 guests.

Reading of minutes dispensed with.

Applications for Active Membership of the following, approved by the Executive Board, were read by name only: Clinton L. Denison, John H. Lesh, David W. Morrow and Albert H. Tait.

The tellers, Messrs. C. W. Brown, Lane and Westcott, reported the election to Active Membership of Mr. William E. Simpson and of the following officers for the ensuing year:

President — Willard Beahan.
Vice-President — Robert Hoffmann.
Secretary — Joseph C. Beardsley.
Treasurer — John H. Fox.
Librarian — Geo. H. Tinker.
Directors (term expires 1910) — Hiram E. Baldwin, William O. Henderer.

Letters from Messrs. Jos. Leon Gobeille, C. H. Benjamin and N. P. Bowler were read by the Secretary.

Printed reports of the Secretary and Treasurer, hereto appended, were submitted and accepted.

The program, hereto appended, shows the manner in which the body was refreshed and the soul uplifted.

Adjourned.

J. S. Beardsley, *Secretary.*

Twenty-eighth Annual Meeting and Banquet of the Civil Engineers' Club of Cleveland at the Cleveland Athletic Club.

Toasts:

Charles H. Wright, presiding.

"I was thinking to-night, as I sat in the cars,
With charmingest prospect of fragrant cigars,
With a sip of good coffee, how mean it would be,
If that cannibal president calls upon me."

Our New President.

Willard Beahan.

"I thank you, Mr. President, you've kindly broke the ice;
Virtue should always be the first, 'till now I've been the vice —
(A *vice* is something with a screw that's made to hold its jaw
'Till some one twists the handle and opens up its maw)."

The Engineer's Relation to Industrial Education.

Dr. Charles S. Howe.

" With a stuffing of praise, and a basting of wit,
You may twitch at your collar, and wrinkle your brow,
But you're up on your legs, and you're in for it now."

Civic Art.

Wm. H. Hunt.

" Little beds of flowers, little pots of paint,
Make a handsome cottage out of one that ain't."

Engineering and the Law.

Newton D. Baker.

" Come you of the law, who can talk, if you please,
Till the man in the moon will allow it's a cheese,
And tell of the lady, ' that never tells lies,
And stands with a kerchief tied over her eyes.' "

Music.

Engineering Accomplishments of the Year.

President's Address.

"Close the door and dim the light,
I shall not read to you to-night.
No, I am not sleepy, near —
Do not go, stay with me here.
In the darkness of the place
I'll a season's progress trace."

Financial Reports of Secretary and Treasurer for Year ending February 29, 1908.

Secretary's Report.

Permanent Fund.

Balance, March 1, 1907		$1 132.52	
Fees	$140.00		
Interest	42.36	182.36	
Transferred to General Fund			$150.00
Balance, February 29, 1908			1 164.88
Total		$1 314.88	$1 314.88

General Fund.

Balance, March 1, 1907		$202.23	
Dues, Active	$1 862.50		
Associate	112.00		
Corresponding	125.00		
Delinquent	201.50	2 301.00	
1906 bills			$327.15
Rentals		486.00	1 000.00
Billiards		66.95	59.00
Keys		.50	
Advertising		97.00	4.00
Books and periodicals			121.10
Program			122.20
Running expenses			51.20
Journal		25.50	139.74
Furniture and fixtures		315.75	677.86
Printing		12.00	298.70
Postage			96.35
Stationery			25.92
Carried forward		$3 506.93	$2 923.22

Brought forward		$3 506.93	$2 923.22
Secretary			200.00
Telephone (extra name)			9.00
Taxes			12.88
Commissions			9.20
Repairs			14.50
Custodian			337.00
Transferred from Permanent Fund		150.00	
Balance, February 29, 1908			151.13
		$3 656.93	$3 656.93

Summary.

March 1, 1907, balance, Permanent Fund	$1 132.52	
March 1, 1907, balance, General Fund	202.23	
Receipts, Permanent Fund	182.36	
Receipts, General Fund	3 454.70	
Andrew Carnegie	1 000.00	
Disbursements, Permanent Fund		$150.00
Disbursements, General Fund		3 505.80
February 29, 1908, balance, Permanent Fund		1 164.88
February 29, 1908, balance, General Fund		151.13
February 29, 1908, Library (Proposed Fund)		1 000.00
	$5 971.81	$5 971.81

Bills Receivable.

From members (dues)	$356.50
Other clubs	169.00
Billiards	7.65
Miscellaneous	.80
	$533.95

Bills Payable.

Association of Engineering Societies	$131.00
Caxton Building Company	201.32
	$332.32

Respectfully submitted,

JOE. C. BEARDSLEY, *Secretary.*

TREASURER'S REPORT.

Permanent Fund.

Receipts:			
Balance on hand March 1, 1907	$1 132.52		
Entrance fees	140.00		
Interest	42.36		
		$1 314.88	
Expenditures:			
Transferred to General Fund		150.00	
Balance on hand February 29, 1908		$1 164.88	$1 164.88

General Fund.

Receipts:			
Balance on hand March 1, 1907	$202.23		
From Secretary to February 29, 1908	3 304.70		
From Permanent Fund	150.00		
From Andrew Carnegie	1 000.00	$4 656.93	
Expenditures		3,505.80	
Balance on hand February 29, 1908		$1 151.13	$1 151.13
Grand total on hand February 29, 1908			$2 316.01

Respectfully submitted,

R. O. ROTE, *Treasurer.*

Boston Society of Civil Engineers.

Boston, Mass., February 19, 1908. — A regular meeting of the Boston Society of Civil Engineers was held at Lorimer Hall, Tremont Temple, at 7.45 o'clock P.M., President E. W. Howe in the chair. One hundred and twenty members and visitors present, including ladies.

On motion of Mr. J. C. Chase the reading of the records of the last meeting was dispensed with.

Messrs. Thomas G. Hazard, Jr., Walter T. Wiley and Dana M. Wood were elected members of the Socicty.

At 8 o'clock a joint meeting with the Appalachian Mountain Club was held and the President invited Mr. Gardner M. Jones, President of the Appalachian Mountain Club, to assumc the chair.

Mr. Jones then presented the speaker of the evening, Mr. Allen Hazen, a member of both societies, who gave a very interesting description of " A Short Trip in Australia," which was illustrated by a large number of lantern slides.

Adjourned.

S. E. Tinkham, *Secretary.*

Sanitary Section.

The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the Society rooms Wednesday evening, March 4, 1908, with thirty-five members present.

The report of the Executive Committee was read by the chairman and was accepted and placed on file.

The report of the Run-off Committee was read by the chairman of the committee and was acceptcd and placed on file.

Upon motion of Mr. H. K. Barrows it was voted that the Run-off Committee be continued and that Messrs. Arthur T. Safford and William S. Johnson be added to the committee.

Upon motion of Mr. H. P. Eddy, it was voted that a committee of three bc appointed by the chair to collect sewerage statistics and prepare them for publication. The chair appointed Messrs. H. P. Eddy, Bertram Brewer and Charles Saville as members of this committee.

The following officers were elected for the ensuing year:

Chairman — William S. Johnson.
Vice-Chairman — George A. Carpenter.
Clerk — Irving T. Farnham.
Members of the Executive Committee — Hector J. Hughes, Edgar S. Dorr, Charles R. Felton.

An illustrated talk upon the subject of water power was given by Mr. Arthur T. Safford.

William S. Johnson, *Clerk.*

Annual Report of the Executive Committee of the Sanitary Section.

The Executive Committee of the Sanitary Section makes the following report of the meetings held and attendance during the year 1907–8:

March 6, 1907. Subject: "Wastes from Lowell Gas Light Company's Yard," by Arthur T. Safford. Attendance, 31.

May 1, 1907. Subject: "Run-off from Sewered Areas; Methods Adopted for Securing Data and Results Accomplished." General discussion. Attendance, 38.

June 5, 1907. "Excursion to Sewage Disposal Works and Water Purification Plant at Providence, R. I." Attendance, 38.

November 15, 1907. Subject: "Purification of Boston Sewage; Experimental Results and Practical Possibilities." By Professors C.-E. A. Winslow and E. B. Phelps. Attendance, 61.

December 4, 1907. Subject: "Pollution of Waters at Common Law and Under Statutes." By Charles F. Choate, Jr., Esq. Attendance, 45.

The present number of members of the Section who are also members of the Society is 156; there are 3 associates who are also associates of the main society and 20 who are members of the Sanitary Section only, a total of 179.

The Section through a special committee has already collected sewerage statistics from cities and towns under a uniform method of reporting formulated by the committee, and this work is being continued by the Clerk. The results will be ready for publication within a short time.

The Section through another committee appointed for the purpose is now at work upon the run-off from sewered areas and this committee has already made and published a preliminary report. The Section is very fortunate in having members with enthusiasm enough to devote their time to this work and they should not be allowed to do all the work themselves. All members of the Section to whom a personal appeal for assistance in this work has been made should respond, not only on account of its value to the engineering world at large, but because of the personal interest aroused in experimental work of a very high character.

There are a number of other lines of work, such as "uniform specifications for sewer pipe," which should be given to committees. In order to make the work of this Section valuable and keep up the interest, something should be done each year in the way of original research, for which the time and money should be provided. The committee hopes to see a fund made available for such work, by which these matters can be given the personal attention of some one, a member of the Section, who can be paid for his services.

The committee desires again to call to the attention of the Section the fact that there are not many members of the Section outside of those who are also members of the Boston Society. The Section was organized principally to bring together the engineers and the men who are connected officially with the care and management of sewerage works. It is, therefore, the duty of every one to bring to the attention of such officials, and others interested, the work of the Section and the possibilities of greater activity through an increase in the membership. We must make this a personal duty and increase the number of Section members just as far as possible.

In this connection the Section finds it difficult to get papers from men in actual charge of sanitary work and maintenance, and it is a matter of regret that this should be so. We would urge upon the members the fact that in order to make the work of the Section well balanced, we should be

able to obtain papers and discussions from those members who are fortunate enough to know the practical difficulties in the way of getting good results.

Respectfully submitted,

ARTHUR T. SAFFORD, *Chairman.*

REPORT OF COMMITTEE ON RUN-OFF.

BOSTON, MASS., MARCH 4, 1908. — The Committee on Run-off from Sewered Areas submits the following report of its work during the year 1907:

The work of your committee has been confined almost entirely to investigations, plans and correspondence looking to the establishment of stations for making observations. There have been held five meetings of the committee, which were well attended, and numerous meetings of sub-committees. The committee now has nine stations assured from which observations will be made during 1908, and expects to largely increase this number in the near future.

Early in the year the committee found that it must be prepared to recommend apparatus, give an estimate of the cost and advise as to the installation as well as to the method of collecting and recording the data; and for the purpose of presenting the conclusions of the committee and the information which had been collected to members of the profession who would help in the work by establishing observation stations, submitted a preliminary report on these matters, an important feature of which was the collecting and listing of such papers covering the subject as had already been printed. Printed copies of this report have been widely distributed, and other copies will be furnished upon application.

The committee has received many favorable commendations as to the desirability and value of this work, but has found that many whose co-operation is needed hesitate to install and operate the needed apparatus. This is partly on account of the expense, but probably largely due to the fact that the necessity of collecting this information is not generally understood among members of city governments, and the engineer hesitates to introduce a proposition which will not be appreciated and which may cause criticisms. The committee believes that, in presenting the proposition, it should be represented that the information to be obtained will be of service in answering claims which may be brought against the municipality on account of insufficient drainage or because of overflow from drains already built; that the observations and collated results will be of great value in determining the sizes of storm water drains with more exactness than is now possible and should result in increased ultimate economy in the construction of drainage systems.

This is a work which must necessarily extend over a long period of time, for after a sufficient number of stations have been established, the period of observations must cover at least two years in order to study the results of varying intensities of rainfall. Your committee expects to furnish to each observer compilations of the data as it is collected, together with the conclusions derived from the same. The committee reiterates the statement made in the preliminary report that "while the Sanitary Section, through its committee, has taken the initiative in starting this investigation, the function of the committee will be merely that of a clearing house.

The value of the results must depend upon the number and interest of those who coöperate." Such coöperation by every member of the Section is earnestly solicited.

Respectfully submitted,

LEWIS M. HASTINGS,
IRVING T. FARNHAM,
GEO. A. CARPENTER,
HECTOR J. HUGHES,
HARRISON P. EDDY, *Committee.*

BOSTON, MARCH 18, 1908. — The annual meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock P.M., President Edward W. Howe in the chair, 81 members and visitors present.

The record of the last meeting was read and approved.

Mr. Joseph P. Davis, a past President of the Society, was elected an honorary member, and Messrs. William W. Churchill, Harold P. Farrington, Howard G. Harrison, John F. Peterson and Charles S. Tinkham were elected members of the Society.

The Secretary read the annual report of the Board of Government and, on motion, it was accepted and placed on file.

The Secretary then read his annual report and, on motion, it was also accepted and placed on file.

The Treasurer read his annual report and, on motion, it was accepted and placed on file.

Mr. Street presented and read the annual report of the Committee on Excursions. On motion, the report was accepted and placed on file.

The Librarian read the annual report of the Committee on the Library and, on motion, it was accepted and placed on file.

Mr. Johnson presented and read the annual report of the Committee on Advertisements. On motion, it was accepted and placed on file.

The Secretary read a short note from Mr. FitzGerald, Chairman of the Committee on Quarters, stating that the committee had held no meetings during the year, and that "the quarters now at Tremont Temple, while, perhaps, hardly as satisfactory as we might wish, do not seem to call for an immediate change." On motion, the report was accepted.

The Secretary read the following communication, entitled "A plea for a larger membership and a club house":

To the Members of the Boston Society of Civil Engineers:

The writer wishes to bring a matter before the Society that has long been uppermost in his mind. It concerns making the Society more of a social body than he feels that it now is. To make even a suggestion as to any improvement in the running of such an old and well-organized body as the Boston Society of Civil Engineers may seem presumptuous, but the writer hopes that any suggestions or criticisms that follow will be received in the spirit that they are offered.

To begin with, we do not seem to attract a sufficiently large number of engineers to our membership. During the past twelve months we have had only 46 applications for membership, of which number the writer secured 5, and it was only by strenuous recruiting that he induced these 5 to join our ranks. From 1904 to 1907 the Boston Society gained in membership only 7½ per cent., whereas the American Society of Civil Engineers, for example, showed a gain of about 34 per cent. in the same period.

In May, 1907, our Society had 628 members, of whom about 280 were

registered from Boston proper, about 450 from Massachusetts and the rest, about 180, from points outside the state. Our membership in Boston proper, not to mention "Geater Boston," seems to the writer to be too small. Statistics show that there were, in 1907, 125 civil engineering graduates from the Massachusetts Institute of Technology registered from Boston. There are no doubt three times that number here who have spent some time at the Institute. Add to this legion the numerous engineers who followed other branches of the engineering profession at the Institute, the large number of alumni of other technical schools and the great body of able engineers who received no collegiate technical training, and a casual glance, with most modest methods of estimating, will clearly show that we have not one half the resident membership that we ought to have, not only for our own sakes, but for the good of those who have neglected to affiliate with us up to the present time. The same condition of affairs obtains to a greater or less degree throughout the state.

As regards members from outside of Massachusetts, and particularly outside of New England, we can hardly expect to attract many new ones, but we certainly do want to retain the old ones and any present resident members who may move away.

A great many young engineers to whom the writer has suggested membership have declined on the ground that they preferred to join the American Society of Civil Engineers. The main attractions that the American Society possesses for a non-resident member are a supposed prestige and the excellent literature furnished. The effect of these attractions on some of the younger engineers is best shown by the Junior members of the American Society of Civil Engineers registered from Boston in 1907. Of nine such members only one belongs to both societies, whereas of the 100 corporate members of the American Society, 72 are also members of the Boston Society. Can we not attract the younger engineers to our Society before they seek membership in the great national society?

The question naturally arises as to how to increase our membership. At present this depends almost entirely on the individual efforts of the members of the Society, and there is not the slightest doubt that with each resident member acting as a committee of one, at least two hundred desirable new members might be readily obtained during the coming twelve months. This would mean an average of less than one for each member.

The greatest handicap to the social side of our Society seems, to the writer, to be the unsuitable place that we now have for our headquarters and for holding our meetings. To have our meeting place in a temple of Worship, where a certain feeling of restraint antagonistic to good-fellowship is ever present, seems decidedly incongruous. A new and suitable home seems to be the only true solution, and that at an early date.

That the rank and file of our Society are social beings, seeking recreation and good-fellowship as well as technical instruction and entertainment, is clearly evinced by the attendance both at meetings and on excursions where the purely technical part is judiciously tempered with sociability. We have only to refer to the large attendance at such functions to conclusively prove this statement.

The writer has no particular suggestions to make as to the exact method to pursue in arranging for the acquisition of a suitable club house. He hopes, however, that the Society will give the matter even more earnest consideration than heretofore and that the score or more gentlemen, already members for more than a third of a century, whom we are fortunate in now honoring as so-called "original" members, may all be with us when we dedicate the building to be used as a permanent home for the Boston Society of Civil Engineers.

Luzerne S. Cowles,
Member Boston Society of Civil Engineers.

Boston, March 18, 1908.

After a discussion of the subject-matter of the communication, on motion of Mr. Fernald, it was voted: "That a special committee of five

be appointed to investigate and report upon the question of securing new quarters along the lines outlined in the communication of Mr. L. S. Cowles, of March 18, 1908." It was also voted that the incoming President be requested to appoint this committee.

On motion of Mr. Adams, the recommendation of the Board of Government appropriating the sum of $50 for standard engineering books was adopted.

On motion, duly seconded, it was voted to refer to the Board of Government, with full powers, the continuation and appointment of the several special committees of the Society.

Messrs. Mayo T. Cook and John N. Ferguson, the tellers of election, reported the results of the letter ballot and in accordance with their report the following officers were declared elected:

President — Joseph R. Worcester.
Vice-President (for two years) — Henry F. Bryant.
Secretary — S. Everett Tinkham.
Treasurer — William S. Johnson.
Librarian — Frederic I. Winslow.
Director (for two years) — George Bowers.

Mr. William F. Williams then read the paper of the evening entitled, "The Abolition of Grade Crossings in New Bedford." The paper was illustrated by lantern slides.

Adjourned. S. E. Tinkham, *Secretary.*

Twenty-sixth Annual Dinner.

The twenty-sixth annual dinner of the Boston Society of Civil Engineers was served at the Hotel Vendome, Boston, Tuesday evening, March 10, 1908, and was attended by 161 members and guests. The usual informal reception was held at six o'clock and the dinner was served at seven o'clock.

The special guests of the Society were Mr. Charles Macdonald, President American Society of Civil Engineers; Mr. Fred. J. Miller, Vice-President American Society of Mechanical Engineers; Hon. Walter C. Wardwell, Mayor of Cambridge; President Arthur A. Noyes of the Massachusetts Institute of Technology; Hon. Charles F. Choate, Jr., of Boston; Mr. Frank B. Gilbreth, of New York, and Mr. Sylvester Baxter, Secretary of the Metropolitian District Improvement Commission.

A pleasing innovation at this year's dinner took the form of some original verses contributed by members of the Society and fitted to popular tunes, which were sung, between the courses, by those present, led by a quartet of members.

At the conclusion of the dinner the President of the Society, Mr. Edward W. Howe, introduced successively the several speakers: Mr. Macdonald, who brought the fraternal greetings of the American Society of Civil Engineers; Mr. Miller, who spoke for the Mechanical Engineers and urged the formation of a mechanical section of the Society; Mayor Wardwell, who alluded to the days when he was associated in civil engineering work with some of the members whom he saw present; and Mr. Choate, who spoke for the legal profession.

Mr. Wm. E. McClintock, a past president of the Society, reminded members that at the dinner a year ago the full program could not be carried out owing to the sickness of the perennial committee on dinner,

Mr. Manley, and the gift which had been prepared to present him at th dinner was sent to his house. He felt that the members would be glad to hear now the word from Mr. Manley which was missed last year. Mr. Manley on rising was received by hearty applause and another musical effusion from those present. Mr. Manley expressed his appreciation of the many honors which the Society has conferred upon him, of the confidence which had been placed in him by the call to arrange the annual dinner for these twenty-six years and above all for the beautiful gift which had been sent him a year ago, coming at the time when such a remembrance struck a more responsive chord, if possible, than at any other time. Music was furnished by the Albion Quartet.

Annual Report of the Board of Government for the Year 1907–1908.

Boston, Mass., March 18, 1908.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the constitution, the Board of Government submits its report for the year ending March 18, 1908.

At the last annual meeting the total membership of the Society was 635, of whom 600 were members of the Society, 2 honorary members, 13 associates and 20 were members of the Sanitary Section only.

During the year the Society has lost a total of 21 members: 12 by resignation, 6 by forfeiture for non-payment of dues and 3 have died.

There have been added to the Society during the year a total of 36 members in all grades; 33 by election and 3 by reinstatement.

The present membership of the Society consists of 1 honorary member, 13 associates and 636 members, of whom 18 are members of the Sanitary Section only; making the total membership 650.

Record of deaths during the year is:

Charles H. Haswell, honorary member, died May 12, 1907.

Frank W. Upham, died May 3, 1907.

Alfred E. Nichols, died July 31, 1907.

In the death of Mr. Haswell the Society lost its oldest member, one whose membership dates from June 3, 1850, a record of nearly fifty-seven years.

Ten regular meetings of the Society have been held during the year, and the twenty-sixth annual dinner was given at the Hotel Vendome on March 10, 1908. The average attendance at the regular meetings was 76, the largest being 120 and the smallest 35. The attendance at the annual dinner was 161.

At the regular meetings the following papers have been read:

March 20, 1907. — President Frank W. Hodgdon, "Difficulties Encountered in Early Surveys of the State of Massachusetts; How They were Overcome and the Results Obtained."

April 17, 1907. — Memoir of Nelson Spofford, by committee of the Society. Mr. George B. Francis, "Pennsylvania Terminal Station in New York City and the Engineering Problems Connected Therewith." (Illustrated.)

May 15, 1907. — Memoir of John E. Cheney, by committee of the Society. Mr. Thomas MacKellar, "The Simplex System of Concrete Piling" (Illustrated); Mr. Charles R. Gow, "Concrete Piles" (Illustrated).

June 19, 1907. — An illustrated talk by Mr. Desmond FitzGerald.

September 18, 1907. — Memoirs of Charles H. Haswell and Frank W. Upham, by committees of the Society. Mr. Herman K. Higgins, " Panama from the Human Side." (Illustrated.)

October 16, 1907. — Mr. Edward W. DeKnight, of New York, " Waterproof Engineering." (Illustrated.)

November 20, 1907. — Mr. Stephen Child, " Civic Centers and the Grouping of Public Buildings, with Suggestions for Boston." (Illustrated.)

December 18, 1907. — Mr. W. M. Davis, of Boston, " Economical Lubrication in Large Plants"; Mr. E. G. Bailey, of Boston, " Furnace Design in Relation to Fuel Economy."

January 20, 1908. — Mr. H. A. Carson and Mr. Wm. J. Wilgus, of New York, " Double Track Railroad Tunnel under the Detroit River at Detroit." (Illustrated.)

February 19, 1908. — Mr. Allen Hazen, " A Short Trip in Australia." (Illustrated.)

Four informal meetings have been held in the Society's library during the year.

December 11, 1907. — Discussion " on Methods of Finishing Concrete Surfaces," opened by Prof. L. J. Johnson.

January 8, 1908. — " Difficulties Encountered in the Town Boundary Survey and the Application of Plane Table Work to Portions of the Survey," by Mr. Henry B. Wood.

January 29, 1908. — " Description of a Concrete Steel Parkway Bridge in Cambridge," by Mr. Lewis M. Hastings.

February 12, 1908. — Discussion of papers read at the December meeting on " Lubrication of Large Plants," and on " Furnace Design in Relation to Fuel Economy."

From the Treasurer's report it will be learned that the finances of the Society are in good condition and that there has been a substantial gain in the Permanent Fund and in the unexpended balance of the Current Fund. A change has been made in the investment of about ten thousand dollars of our Permanent Fund. This was made necessary by the maturing of shares in coöperative banks and the near approach to the legal limit of our accounts in some of the savings banks. The reinvestments were made by the Treasurer by direction of the Board and with the advice of a special committee appointed for the purpose.

The lease of our quarters will expire on June 1, next. As the changes made at the time of the last renewal of our lease have afforded sufficient space for the probable growth of the library during the next three years, the Board recommends a renewal of the lease for that time.

The report of the Executive Committee of the Sanitary Section shows that the Section has had a successful year, with the usual number of meetings, which have been well attended and been of considerable interest and profit. Experience thus far shows the wisdom of the establishment of this Section, and it is the opinion of the Board that it would be of great benefit to the Society if sections interested in other special branches could be organized.

The Board endorses the recommendation of the Library Committee that the practice of buying standard engineering books be continued, and that the sum of $50 be appropriated for that purpose for the coming year.

For the Board of Government,

Edward W. Howe, *President.*

Abstract of the Treasurer's and the Secretary's Reports for the Year 1907–1908.

CURRENT FUND.

Receipts:

Dues for 1905–1906	$13.00	
Dues for 1906–1907	8.00	
Dues for 1907–1908	3 992.00	
Dues for 1908–1909	101.00	
Rent of rooms	1 000.00	
Advertisements	595.00	
Library fines	3.25	
Permanent Fund, payment of loan	63.95	
Balance on hand, March 20, 1907	385.69	
		$6 161.89

Expenditures:

Rent	$1 995.00	
Lighting	31.03	
Association of Engineering Societies	1 272.00	
Printing, postage and stationery	986.62	
Salaries of Secretary, Librarian and Custodian	550.00	
Reporting meetings	128.38	
Stereopticon	90.00	
Annual dinner	80.60	
Books	41.75	
Binding	97.25	
Periodicals	26.50	
Furniture and repairs	28.00	
Advertisements in JOURNAL	15.00	
Incidentals	229.73	
		5 571.86
Balance on hand, March 18, 1908		$590.03
Amount to the credit of Current Fund, March 20, 1907		449.64
Excess of receipts over expenditures		$140.39

PERMANENT FUND.

Receipts:

Thirty-three entrance fees	$330.00	
Interest on deposits in savings banks	270.08	
Interest on bonds	126.00	
Interest on deposits in trust company	19.26	
Subscription to Building Fund	100.00	
Workingmen's Co-operative Bank, 21 matured shares	4 228.35	
Volunteer Co-operative Bank, 25 matured shares	5 033.75	
Withdrawn from savings banks	4 500.00	
		$14 607.44

Expenditures:

Merchants' Co-operative Bank, dues on 25 shares,	$300.00	
Volunteer Co-operative Bank, dues on 25 shares .	275.00	
Workingmen's Co-operative Bank, dues on 25 shares	321.00	
Franklin Savings Bank, deposit	34.58	
Warren Institution for Savings, deposit	51.72	
Boston Five Cents Savings Bank, deposit	51.18	
Provident Institution for Savings, deposit	38.87	
Eliot Five Cents Savings Bank, deposit	49.08	
Institution for Savings in Roxbury, deposit	44.65	
$4 000 Boston Elevated Railway Bonds	4 038.00	
$3 000 American Tel. & Tel. Co. Bonds	2 371.08	
$3 000 C. B. & Q. Joint Bonds	2 553.75	
Twenty-one shares Volunteer Co-operative Bank,	2 895.00	
Current Fund, repayment of loan	63.95	
		13 087.86
Balance on hand, March 18, 1908		$1 519.58

PROPERTY BELONGING TO THE PERMANENT FUND, MARCH 18, 1908.

Twenty-five shares Merchants' Co-operative Bank	$3 051.16
Twenty-five shares Volunteer Co-operative Bank	3 099.40
Twenty-five shares Workingmen's Co-operative Bank	516.44
Deposit in Franklin Savings Bank	487.46
Deposit in Warren Institution for Savings	732.21
Deposit in Boston Five Cents Savings Bank	703.65
Deposit in Provident Institution for Savings	688.99
Deposit in Eliot Five Cents Savings Bank	546.18
Deposit in Institution for Savings in Roxbury	509.95
Republican Valley Railroad Bond, 6% par value	600.00
Boston Elevated Railway Bonds, 4½% par value	4 000.00
C. B. & Q. Railroad Joint Bonds, 4% par value	3 000.00
American Tel. & Tel. Co. Bonds, 4% par value	3 000.00
Cash on deposit	1 519.58
Total Permanent Fund	$22 455.02
Amount of fund as per last annual report	20 058.27
* Gain during the year	$2 396.75

TOTAL PROPERTY OF THE SOCIETY IN THE POSSESSION OF THE TREASURER.

Permanent Fund	$22 455.02
Current Fund	590.03
Total	$23 045.05
Amount as per last annual report	20 507.91
* Increase during the year	$2 537.14

* Of this gain, $1 037.17 is the difference between the par value of the bonds purchased and the amount paid for them.

Report of Committee on Excursions.

Boston, March 18, 1908.

To the Members of the Boston Society of Civil Engineers:

The Committee on Excursions herewith respectfully submits its annual report.

Ten excursions have been made during the past year, as follows:

May 15, 1907. — Concrete Piles at the Milton Car Barns of the Boston Elevated Railway. Attendance, 28.

August 7, 1907. — Turbine Steamer *Yale*. Attendance, 38.

August 22, 1907. — With United States Army Engineers. Inspection of dredgers and Fort Warren. Attendance, 137.

September 7, 1907. — Excursion to Wonderland Park. Attendance, 80.

September 18, 1907. — Inspection of Hassam Pavement laid by Simpson Brothers, in Cambridge. Attendance, 8.

October 19, 1907. — Blue Hill Observatory. Attendance, 42.

October 29, 1907. — Inspection of concrete buildings built by Benj. Fox for the Boston Woven Hose and Rubber Company, Cambridge. Attendance, 40.

November 15, 1907. — Fore River Ship Building Company. Attendance, 50.

December 18, 1907. — Inspection of concrete buildings of Robb-Mumford Company and Richard H. Long Company, at South Framingham. Attendance, 12.

February 19, 1908. — Inspection of work on the Lawrence and Wiggin Wharf at Charlestown. Attendance, 5.

Total attendance, 440; average attendance, 44.

Thirty-two and one-half pages of the *Bulletin of New Engineering Work* and seven pages of *Personal Notes*, or a total of thirty-nine and one-half pages, have been published during the past year, as against thirty-six pages for the previous year.

There is a cash balance of $18.90 in the hands of the Treasurer.

The committee wishes to thank all those who have aided in this work and to express its wish that members at all times will be free to send suggestions for excursions and items for the *Bulletin of New Engineering Work* and the column of *Personal Notes*.

Respectfully submitted,

L. Lee Street, *Chairman*,
Eugene E. Pettee,
Clarence T. Fernald,
Laurence B. Manley,
Edmund M. Blake, *Sec'y and Treas.*

Report of the Committee on the Library.

The annual report of the Committee on Library is herewith submitted:

During the past year there have been added to the library 200 volumes bound in cloth, making a total of 6,258. Of this number 25 were bought, 43 were bound current magazines and 132 were gifts to the Society.

There were 432 volumes in paper added to the library, mainly consisting of reports and bulletins.

An attempt was made, involving considerable labor, to complete our files of town and city reports, and these have now been completed about as far as is practicable. This work was done by one of the members of the committee, and it involved sending out sixty printed requests to the various towns and cities.

The Librarian has felt obliged to enforce the rules regarding fines for books kept overtime and also to disallow the borrowing of books in constant demand, such as those on reinforced concrete, and handbooks such as Kent, Trautwine, etc.

During the year, 155 books have been borrowed from the library.

The committee recommends that the sum of $50 be allowed the coming year for the purchase of current engineering publications.

Respectfully submitted,

FREDERIC I. WINSLOW,
CHARLES SAVILLE,
HERBERT R. STEARNS,
NATHAN S. BROCK,
Committee.

REPORT OF THE COMMITTEE ON ADVERTISEMENTS.

BOSTON, March 18, 1908.

To the Boston Society of Civil Engineers:

The Advertising Committee begs to submit the following report:

At the present time there are 41 advertisements carried in the *Monthly Bulletin*, which yield $910.00 per year, and three advertisements in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, netting the Society $135.00, making a total revenue for advertisements of $1,045.00 per year.

The amount of advertising carried is somewhat smaller than the amount reported last year. The decrease is due in part to business conditions, but chiefly to the decrease in activity on the part of the Advertising Committee. This lethargy in turn may be explained in part by the fact that with even the present amount of advertising a surplus in the treasury is assured, so that the incentive of last year is now lacking.

It has been suggested by some of the members of the Society that advertising in the *Bulletin* is a species of graft, but it seems to your committee, from the responses which are received from advertisers, that the *Bulletin* is one of the best mediums for certain classes of advertising and, on the other hand, that besides producing a much-needed revenue, the advertising makes the *Bulletin* more attractive.

WILLIAM S. JOHNSON,
S. E. TINKHAM,
F. A. BARBOUR,
Committee.

Montana Society of Engineers.

Butte, Montana, February 8, 1908. — The February meeting of the Society was called to order by Vice-President Chas. H. Bowman, at the usual hour and place. Quorum present. The minutes of the Twenty-First Annual Meeting were approved as read. The application of Worden Irvin Higgins for membership in the Society was read, approved and the regular ballot ordered. Messrs. Tannatt, Kneale, Dearborn, Flaherty, Locke, Sacket and Davis were elected to membership by a unanimous vote. The Secretary read letters from the Montana Congressional Delegation concerning House Bill No. 9230, a bill to establish engineering experiment stations at land grant colleges. The balance of the meeting was devoted to the reading of a paper by the Secretary, written by Ex-President Joseph H. Harper, entitled, " My Impressions of the San Francisco Earthquake." The Society instructed the Secretary to have the paper published in one of the daily papers of the city, thus showing their appreciation of Mr. Harper's thesis.

Adjournment followed.

Clinton H. Moore, *Secretary.*

Association of Engineering Societies.

Vol. XL. APRIL, 1908. No. 4.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, March 4, 1908. — The 647th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, March 4, 1908, at 8.30 o'clock, President Brenneke in the chair. There were present thirty-one members and five visitors.

The minutes of the 646th meeting were read and approved.

The minutes of the 438th meeting of the Executive Committee were read.

The Secretary read a letter from Mr. B. W. Frauenthal, secretary of the St. Louis Railway Club, announcing that 250 copies of the Proceedings of that organization, containing Professor Breckenridge's article on "How to Burn Bituminous Coal without Smoke," had been sent to the Engineers' Club for distribution. On motion of Mr. William H. Bryan, duly seconded, it was unanimously voted to extend the thanks of the Engineers' Club to the Railway Club for this courtesy.

A letter from Mr. C. D. Purdon was read, announcing the death of Mr. James Dun, a member of the Club. The President appointed Messrs. C. D. Purdon and J. F. Hinckley a committee to draw up a memorial to be presented at the next meeting.

The following were elected: Bunton, Fred L. (member); Bulkeley, Rolla C. (member); Wyld, Robert H. (member); McCully, William J. (associate member); Burgess, Harold C. (junior member).

It was announced that the complimentary dinner to Mr. M. L. Holman, in recognition of his election to the presidency of the American Society of Mechanical Engineers, would be held on Saturday evening, March 7, at the Missouri Athletic Club.

The paper of the evening on "Timber Preservation" was presented jointly by Messrs. A. L. Kamerer and E. B. Fulks. Mr. Kamerer first presented a paper describing the different methods in use for preserving timber, especially railway ties, and Mr. Fulks followed with a large number of slides illustrating various preserving plants in various parts of the United States and Europe.

A discussion that followed was participated in by Messrs. R. H. Phillips, A. P. Greensfelder, E. B. Fulks and others.

Adjournment.

A. S. Langsdorf *Secretary.*

St. Louis, March 7, 1908. — Special. On the evening of March 7, 1908, the Engineers' Club of St. Louis tendered a complimentary dinner to Mr. Menard Lefevre Holman, in recognition of his election to the presidency of the American Society of Mechanical Engineers. The dinner was served at the Missouri Athletic Club, Fourth Street and Washington Avenue, at 7.30 P.M., the total attendance being fifty-four, including members of the Club and representatives of the three national societies of Civil, Mechanical and Electrical Engineers. In the absence of President W. G. Brenneke, who was compelled to be out of the city, Vice-President E. E. Wall presided as toastmaster.

After an enjoyable repast, regular toasts were responded to as follows: Introductory Remarks, the Vice-President, Mr. E. E. Wall; Response, for the Engineers' Club of St. Louis, Mr. W. A. Layman; Response, for the Civil Engineers, Mr. Robert Moore; Response, for the Electrical Engineers, Col. E. J. Spencer; Response, for the Washington University, Dr. C. M. Woodward; "Our Guest," Mr. M. L. Holman.

At the conclusion of the regular toasts, Mr. B. H. Colby, Mr. R. S. Colnon, and Mr. S. Bent Russell responded informally when called upon for remarks.

The meeting adjourned at about 11 P.M., after a thoroughly enjoyable evening.

A. S. Langsdorf, *Secretary.*

St. Louis, March 18, 1908. — The 648th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, March 18, 1908, at 8.30 o'clock, Vice-President E. E. Wall in the chair. There were present about thirty members and visitors.

The minutes of the 647th meeting were read and approved.

The minutes of the special meeting of March 7, the complimentary dinner to Mr. M. L. Holman, were read and approved.

The minutes of the 439th meeting of the Executive Committee were read.

The Secretary read the report from Messrs. Holman and Pitzman, delegates to the Joint Conference on Charter Revision, to the effect that it had been decided to ask for a new charter for the city, the present one being out of date and inadequate; on motion, duly seconded, the report was ordered filed.

The Secretary read a letter from the St. Louis Chemical Society transmitting resolutions regarding continuance of the Fuel Testing Plant at St. Louis, and on motion of R. H. Phillips, duly seconded, it was referred to the Committee on Fuel Testing Plant.

There were no reports from Messrs. Purdon and Hinckley, committee appointed to draw up resolutions on the death of James Dun, and they were granted further time.

The following applications were received: Cameron, Bruce (associate member); Burgess, Joseph E. (member).

No other business appearing, the paper of the evening, on the "Fire Resisting Qualities of Building Stone," was presented in a very able manner by Prof. W. E. McCourt, of the Geological Department of Washington University. Mr. McCourt treated the subject in a most thorough and capable manner. giving a preliminary talk on the classification of

stones and the characteristics of a good building-stone, and continuing by giving the result of numerous experiments on the building stones of New York, New Jersey, Wisconsin, Michigan, Illinois and Missouri which had been made by him at various times. A number of stereopticon views showing the effects of heat upon these stones, and views of the effect of the Baltimore fire on building stones were interspersed through the discourse.

The discussion that followed was participated in by various members.

H. E. Grimm, *Secretary pro tem.*

St. Louis, April 1, 1908. — The 649th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, April 1, 1908, at 8.30 o'clock. President W. G. Brenneke in the chair. There were present thirty-eight members and eight visitors.

The minutes of the 648th meeting were read and approved.

The following applications were presented: Wilbur, Ralston Thornton (member); Schueddig, Edward (associate member).

The following were elected: Burgess, Joseph E. (member); Cameron, Bruce (associate member).

It was announced that Colonel Sears of the United States Engineers' Office had presented to the Club Library a set of 157 volumes of the Reports of the Chief of Engineers, United States Army, dating from 1866. The Secretary announced that the donation had been properly acknowledged.

There being no further business, the paper of the evening on Settling Basins 7 and 8, Chain of Rocks, was presented jointly by Mr. G. G. Black and Mr. A. P. Greensfelder. Mr. Black described the basins, which are of reinforced concrete, from the standpoint of their design and gave numerous figures relating to the stresses allowed in different parts of the structure. Detail points of design were illustrated by numerous lantern slides. Mr. A. P. Greensfelder then gave a description of the methods used in the actual construction work, illustrating by lantern slides made from photographs taken as the work progressed.

The discussion which followed was participated in by a considerable number of those present.

Adjourned.

A. S. Langsdorf, *Secretary.*

Boston Society of Civil Engineers.

Sanitary Section.

A special meeting of the Sanitary Section was held at the Boston City Club, Wednesday evening, April 1, 1908. Mr. W. S. Johnson, Chairman, presided, forty-six members and guests being present.

The recommendations contained in the annual report of the Executive Committee, presented by Mr. A. T. Safford, the retiring Chairman, were considered, and upon motion of Mr. Leonard Metcalf, it was voted to authorize the Chairman to appoint a committee of five to consider the

subject of Uniform Specifications for the Manufacture of Vitrified Sewer Pipe; the committee, if it finds it infeasible for the Section to adopt such specifications, to so report. The Chairman has appointed as this committee: Messrs. Leonard Metcalf, F. A. Barbour, L. D. Thorpe, E. S. Dorr and Charles R. Felton.

The following report of the Committee on Uniform Sewerage Statistics was submitted:

Boston, Mass., April 1, 1908.

Mr. William S. Johnson,
Chairman, Sanitary Section, Boston Society of Civil Engineers:

Sir, — The Committee on Uniform Sewerage Statistics appointed by you at the annual meeting of the Section on March 4, 1908, presents the following report:

This committee was asked to undertake the work of collecting statistics relative to sewerage and sewage disposal in the various cities throughout this part of the country, and to arrange the data obtained in such form that it would be of value to engineers and city authorities.

It was found that considerable work in this connection had already been done by the present chairman of the Section, and that the information obtained, which was for the year 1906, had been tabulated. An examination of these tables has shown them to be of considerable interest. The committee has made some slight changes in their arrangement and has also attended to the work of reviewing and editing which would be necessary before they could be printed.

In view of the fact that the statistics thus far obtained will be useful to engineers in general, as well as to the members of this Section, we suggest that the main Society be requested to authorize the Section to have this table and similar tables which shall be prepared for subsequent years printed in the Journal of the Association of Engineering Societies. It is also desirable that extra copies be published for distribution among those who do not receive the Journal, but whose coöperation it is desired to secure.

The committee is now at work collecting statistics from as many cities as possible for the year 1907 to be tabulated in a similar manner to those obtained for the previous year.

Respectfully submitted,

Harrison P. Eddy.
Bertram Brewer.
C. Saville.

Upon motion of Mr. Charles W. Sherman, it was voted to accept the report and adopt the recommendations of the committee. The clerk was instructed to request the early publication of the report, together with the tabulated information which the committee has obtained, in the Journal of the Association of Engineering Societies, and to request that extra copies be furnished for the use of the committee.

Mr. George R. King gave a very interesting talk upon Alaska, illustrated by a large number of lantern slides. The meeting tendered a vote of thanks to Mr. King.

Irving T. Farnham, *Clerk.*

Boston, Mass., April 15, 1908. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.30 o'clock P.M., President Joseph R. Worcester in the chair. One hundred and sixty-four members and visitors present.

The record of the last meeting was read and approved.

Messrs. David R. Bates, Austin Cary, James H. Eaton, John A. Garrod, Timothy Guiney, Henry M. McCue, Frederic L. Murray, Edgar A. Norwood, Charles C. Turner and Howard E. Whiting were elected members of the Society and Mr. J. Howard Hayes was elected an associate.

The Secretary announced that under authority of a vote passed at the annual meeting the President had appointed the following special committee to consider the matter presented to the Society in the communication of Mr. Cowles, in relation to increase of membership and clubhouse: L. S. Cowles, G. A. Carpenter, C. R. Gow, R. E. Curtis and C. B. Breed.

The Secretary reported for the Board of Government that under authority of the vote referring to the Board, with full powers, the continuation and appointment of the several special committees of the Society the Board had voted to continue the Committees on Excursions, on the Library and on Quarters, and to discontinue the Committee on Advertisements. The committees as appointed are as follows: —

On Excursions. E. E. Pettee, E. M. Blake, L. B. Manley, R. W. Loud and J. A. Starr.

On the Library. F. I. Winslow, N. S. Brock, W. T. Barnes, M. T. Cook and H. A. Varney.

On Quarters. Desmond FitzGerald, E. W. Howe, G. A. Kimball, F. W. Dean and F. W. Hodgdon.

The Board also appointed the following to represent the Society on the Board of Managers of the Association of Engineering Societies, in addition to the Secretary who is *ex-officio* a member: Dexter Brackett, C. W. Sherman, G. A. Kimball, H. P. Eddy and A. T. Safford.

The Secretary also reported for the Board that it recommended to the Society that the sum of $50 be appropriated for the use of the Committee of the Sanitary Section on Run-Off of Sewered Areas. The report was accepted and on motion of Mr. Johnson, it was voted, That the Sanitary Section be authorized to expend a sum not exceeding $50 for the work of the Committee of the Section on Run-Off of Sewered Areas.

Mr. George A. Nelson, for the committee appointed to prepare a memoir of Alfred E. Nichols, a member of the Society, presented and read its report.

The President announced the death of William Vaughan Moses, a member of the Society, which occurred on April 14, 1908. By vote the President was requested to appoint a committee to prepare a memoir. The President has appointed as the committee, Prof. Frank L. Kennedy.

The Secretary read a communication from the Chamber of Commerce of Pittsburg urging early action by the Society approving the calling of a conference by the President upon the subject of the Conservation of the Natural Resources of the United States. After a brief discussion and the passage of a vote expressing the approval of the meeting of the proposed investigation of the subject, it was voted to refer the communication to the Board of Government with full power for action.

Mr. Cowles for the committee appointed to consider the question of larger membership and a clubhouse submitted a brief report stating that

the committee would not be able to investigate the subject and report its findings before the regular meeting in October next and inasmuch as the present lease of the Society's rooms expires on June 1, it recommended that the same be renewed for one year, with the privilege of further annual renewals, if possible. On motion of Professor Swain the report was accepted and the recommendation adopted.

The President announced that he should endeavor to call the meetings to order promptly at the hour stated in the notice.

Prof. George F. Swain then spoke informally on some points in connection with the Quebec Bridge, illustrating his remarks with a large number of lantern slides. A discussion followed in which Messrs. Cowles, Fay, L. J. Johnson, F. B. Sanborn, J. P. Snow and others took part.

Adjourned.

S. E. Tinkham, *Secretary.*

Montana Society of Engineers.

Butte, Mont., March 14, 1908. — The regular meeting of the Society for the current month was held in Room 16, 225 North Main Street, at 8 p.m. Vice-President Charles H. Bowman presided.

Minutes of previous meeting read and approved.

Mr. W. I. Higgins was elected to membership.

Mr. Robert H. Lindsay, Jr., presented a written protest against the manner of administration and interpretation of Mining Laws on Forest Reserves and, on motion, the paper was referred to the Committee on Revision of Mining Laws.

The Secretary read a paper by Mr. Joseph H. Harper entitled "Aftermath of the San Francisco Earthquake."

The Secretary was instructed to have the paper published in one of the daily papers of the city.

Adjournment followed.

Clinton H. Moore, *Secretary.*

Technical Society of the Pacific Coast.

Regular Meeting held March 20, 1908, at Jules' Restaurant, 328 Bush Street, where the members of the Society assembled at 6.30 o'clock for dinner.

After dinner President George W. Dickie called the meeting to order.

The Secretary read the minutes of the last regular meeting, and of the last Directors' meeting, which were approved.

Mr. Heinrich Homberger read a paper, which he illustrated by lantern slides, entitled "Pressure Fluctuations in Turbine Pipe Lines," which was discussed by Mr. Doble and by the President, who referred to his experiences of past years in relieving the Comstock mines of the accumulated water.

Mr. Homberger's paper was ordered to be sent to the Journal of the Association for publication.

The President referred to the matter that had been suggested in

reference to the cleaning of the city, and to the advisability of donating from the funds of the Society the sum of $250 for this purpose. This caused a general discussion, the opinion being somewhat divided as to the propriety of taking from the limited means of the Society an amount as large as $250.

While some of the members expressed the opinion that no money should be devoted to this end, more of them seemed in favor of setting aside a smaller amount, more in keeping with the limited possessions of this Society.

Professor Kower thereupon moved that it be the sense of this meeting that the sum of $100 be donated to the Citizens Committee for the purpose of cleaning San Francisco, and that in addition to this donation the members be called upon individually to contribute and that these contributions be forwarded to the committee.

The underlying idea of this motion being this: That most members will prefer an individual donation rather than that the funds be drawn upon to the extent originally proposed.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Detroit Engineering Society.

Detroit, Mich., March 27, 1908. — One hundred and eighth regular meeting.

Meeting called to order at 8.10 p.m., President E. S. Wheeler presiding.

Minutes of the 107th regular meeting, of February 28, read and approved.

Mr. A. Geo. Mattsson gave notice that an amendment to the constitution was necessary to make any one an Honorary Member.

The President gave notice that the men appointed to get the speakers for the annual banquet were as follows: Benj. Douglas, Alex. Dow, and Walter Russel.

Moved by W. R. Kales, seconded by B. E. Parks, that the President name the nominating committee for the annual meeting.

Discussion in regard to raising the annual dues from $5 to $6; Messrs. Keep, Blauvelt, Shenehon, Mattsson, etc., took part in the discussion.

Moved in amendment by W. S. Blauvelt, seconded by B. E. Parks, that the annual dues of those that take the Journal be $6 and those that do not take Journal be $5: discussion by Keep, Fenkell, Shenehon, Kales, Mattsson, Parks, etc. Mr. W. S. Blauvelt, with the permission of Mr. B. E. Parks, withdrew his amendment.

Motion to raise dues from $5 to $6. Carried.

Moved by Mr. T. McCrickett, seconded by W. S. Blauvelt, that the Executive Committee define the number of complimentary tickets that each member is entitled to for the annual excursion.

The following candidates were declared elected, Wright B. Thompson, C. F. Coda, A. C. Bornholt.

The paper of the evening was then presented by E. S. Wheeler, on "The Estimated Cost of Building a Pyramid in Detroit Similar to the Great Pyramid of Gizeh." Discussion followed.

Moved by F. C. Shenehon, seconded by G. H. Fenkell, that the paper be printed in the JOURNAL. Carried.

Moved by B. E. Parks, seconded by A. G. Mattsson, that we adjourn. Carried.

BAMLET KENT, *Secretary.*

DETROIT, MICH., APRIL 10, 1908. — Special meeting of the Detroit Engineering Society. Meeting called to order at 8.10 P.M, Second Vice-President A. L. Colby in the chair.

The paper of the evening on "Gas Engines and Gas Producers," with stereopticon views of the various parts, was presented by V. E. McMullen, of the Fairbanks Morse Manufacturing Company, Beloit, Wis. The paper was discussed by the following: Fenkell, Mason (Jackson), Lane, Kales, Collamore, Barthel, Shenehon, Blodgett, Mason (Detroit), Vorce, etc.

Meeting adjourned at 10.20.

BAMLET KENT, *Secretary.*

ASSOCIATION
OF
ENGINEERING SOCIETIES.

VOL. XL. | MAY, 1908. | No. 5.

PROCEEDINGS.

Engineers' Club of St. Louis.

ST. LOUIS, APRIL 15, 1908. — The 650th meeting of the Engineers' Club of St. Louis was held at the club rooms, 3817 Olive Street, on Wednesday evening, April 15, at 8.30 o'clock. President W. G. Brenneke presided. There were present forty-two members and five visitors. The minutes of the 649th meeting were read and approved. The minutes of the 440th meeting of the Executive Committee were read.

The following were elected: Ralston Thornton Wilbur, member; Edward Schueddig, associate member.

The committee, consisting of Messrs. J. F. Hinckley and C. D. Purdon, appointed to draw up a memorial of the late Mr. James Dun, submitted its report.

It was voted that the memorial be spread upon the records and printed in the JOURNAL,* and that a copy be sent to Mr. W. B. Story, chief engineer of the Santa Fé system, for presentation to Mrs. Dun.

The resolutions drawn up by the St. Louis Chemical Society in regard to the continuance of the fuel testing plant having been referred to the Committee on Fuel Testing Plant, with a request that some recommend-ation be made, the committee, through its chairman, Mr. Edward Flad, submitted a report recommending that no action be taken until after the conference called by President Roosevelt on the "Conservation of the Natural Resources" at the White House, May 13, 14, 15, 1908.

There being no further business, the President announced that the program of the evening, a discussion of the "Conservation of the Natural Resources of the United States," was in order, and called upon Mr. M. L. Holman to open the discussion. In his remarks Mr. Holman outlined the plan and scope of the conference to be held in Washington in May, and stated that the work of the conference would probably be along quite general lines. He showed that the whole matter was largely one involving the question of states' rights, and in some cases of international policy, so that much of the work to be done would have to be settled by the courts. But he also stated that there would be a large field for engineers in determining the economic features of work to be undertaken.

* See JOURNAL for April, 1908, page 241.

Col. J. A. Ockerson, having been compelled to be out of the city, submitted a written discussion, which was read by the Secretary. Mr. Ockerson confined himself principally to a discussion of the effect of forest growth upon rainfall and river floods, showing that there was much misinformation on this subject requiring correction. It is practically certain that forests have no effect upon the rainfall, their real value residing in their ability to check the rapidity of the run-off and in preventing erosion.

Mr. Robert Moore discussed the subject of the "Conservation of the National Health," and advocated the establishment of a national bureau of health, one of whose duties would be a systematic collection of vital statistics now almost altogether neglected, especially by the Central, Western and Southern states.

Prof. J. L. Van Ornum spoke of the great importance of preserving the purity of our water supply, and advocated the adoption of systems of sewage purification before its discharge into the rivers.

Mr. William H. Bryan presented a general synopsis of the entire subject, dealing with the subjects of fuel and mineral supply, and proper care of sands and soils and the utilization of natural sources of power.

Mr. C. D. Purdon presented some statistics on the timber supply and stated that different writers estimated that the present available supply of timber would be exhausted in from fourteen to thirty years.

Mr. A. S. Langsdorf stated that the whole subject of conservation of natural resources was very thoroughly discussed in a book called "Man and the Earth," by the late Prof. Nathaniel Shaler, of Harvard University.

The discussion was then brought to a close by Mr. Holman, who gave a brief statement of the probable attitude of the engineering representatives at the forthcoming White House conference.

Adjourned.

A. S. Langsdorf, *Secretary.*

St. Louis, May 6, 1908. — The 651st meeting of the Engineers' Club of St. Louis was held at the Club Rooms, 3817 Oliver Street, on Wednesday evening, May 6, at 8.30 o'clock, President W. G. Brenneke presiding. There were present twenty-three members and thirteen visitors.

The minutes of the 650th meeting were read and approved.

The minutes of the 441st meeting of the Executive Committee were read.

The Secretary read a letter from Mr. C. A. Bulkeley, chairman of the Entertainment Committee, announcing the plans for a series of excursions to be given before the summer recess.

The paper of the evening on "Aids in Railroad-Bridge Designing" was then presented by Mr. S. W. Bowen. Mr. Bowen had prepared a number of charts for the ready determination of such data as moments, shears, economic depths and weights of various forms of trusses, through and deck girders. The charts were prepared for the purpose of minimizing the computations in the design of trusses and floor-beams for any loading and any span, and furnished an excellent illustration of the value of the graphical method. The paper was discussed by Messrs. J. L. Jacobs, E. B. Fay and A. S. Langsdorf.

Adjournment.

A. S. Langsdorf, *Secretary.*

Montana Society of Engineers.

BUTTE, MONT., APRIL 11, 1908. — The Society meeting for April was called to order at 8 P.M. by Vice-President Bowman. Minutes of March meeting approved as read. The applications of Messrs. Hayes, Leggat and Hoffman for membership were presented and on approval the necessary ballots were ordered. The matter of a midsummer meeting was given considerable attention and the Board of Trustees, to whom the subject was referred at the last annual meeting, were invited to present a report at the May meeting of the Society upon the feasibility of holding such a meeting and to suggest a suitable date for the same. The Secretary read a communication from the Chamber of Commerce, Pittsburg, Pa., having for its subject the letter of President Roosevelt inviting the governors of the states and members of Congress to a conference at the White House next May to consider the subject, the "Conservation of the Natural Resources of the United States." The Chamber of Commerce requested the approval of the President's action by this Society if in accord with its views, and on motion the following was adopted:

Whereas, The Montana Society of Engineers, in their business and professional relations with the great industrial enterprises of the country, realize the pressing needs for preserving, correcting abuses and economically using the natural resources of the country; therefore be it

Resolved, That we earnestly request the Governor of Montana and the Senators and Representatives of this state in Congress to attend the conference called by the President of the United States at the White House, May 13–15, 1908, and labor in every way to promote its success; and be it further

Resolved, That the Secretary of this Society send a copy of these resolutions to the Governor of this Commonwealth and the Congressional Delegation of Montana.

Ex-President Kinney gave a talk on some interesting features of an irrigation project under his present supervision in Gallatin County. Mr Goodale reported progress for the Committee on the Revision of Mining Laws.

Adjournment.

CLINTON H. MOORE, *Secretary*.

The Detroit Engineering Society.

DETROIT, MICH., APRIL 17, 1908. — Fourteenth annual meeting of the Detroit Engineering Society.

Meeting called to order by the President at 7.45 P.M.

Minutes of the 108th regular meeting read and approved.

Minutes of special meeting of April 10, 1908, read and approved.

Moved by Mr. G. S. Williams, seconded by Mr. S. G. Barnes, that the Secretary be instructed to cast one ballot for Mr. Francis C. Shenehon for President for the coming year. Carried.

Moved by Mr. Walter S. Russel, seconded by F. P. Johnson, that the Secretary be instructed to cast a ballot for Byron E. Parks for first Vice-President for the coming year. Carried.

Moved by D. M. Mason, seconded by Geo. L. Grimes, that the Secretary be instructed to cast a ballot for Chas. G. Herbert for second Vice-President for the coming year. Carried.

Moved by W. R. Kales, seconded by D. M. Mason, that the President be instructed to cast one ballot for Bamlet Kent for Secretary for the coming year. Carried.

Moved by Benjamin Douglas, seconded by W. R. Kales, that we adjourn to the Hotel Tuller for the annual banquet. Carried.

At the hotel there were one hundred and twenty-three who sat down to the annual dinner, after which Mr. E. S. Wheeler, the retiring President, turned the meeting over to Francis C. Shenehon, the newly elected President, to act as toastmaster. Speeches, etc., were received from Gardner S. Williams, chairman of the Managing Board; Mr. A. F. Nock, Col. C. McD. Townsend, Walter S. Russel, A. Geo. Mattsson and Bingley R. Fales. Mr. Bernard Nagelvoort gave several musical selections.

Meeting adjourned at 12.40 A.M.

BAMLET KENT, *Secretary.*

Association
of
Engineering Societies.

Vol. XL. | JUNE, 1908. | No. 6.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, May 20, 1908. — The 652d meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday evening, May 20, 1908, President Brenneke presiding. There were present thirty-eight members and one visitor.

The minutes of the 651st meeting were read and approved, and the minutes of the 442d meeting of the Executive Committee were read.

The Secretary presented an application for Associate Membership, received from Mr. Oliver B. Barrows.

Mr. A. O. Cunningham, chief engineer of the Wabash Railroad, presented the paper of the evening on " Engine Terminal Facilities Constructed by the Wabash Railroad at Decatur, Ill." Mr. Cunningham described in detail the construction of the roundhouse and the facilities for watering and coaling locomotives, of which about one hundred are handled each day; itemized costs of various parts of the installation were given and the structural details were illustrated by a large number of lantern slides.

Adjournment.

A. S. Langsdorf, *Secretary*.

Boston Society of Civil Engineers.

Boston, Mass., May 20, 1908. — A regular meeting of the Boston Society of Civil Engineers was held in Chipman Hall, Tremont Temple, at 7.30 o'clock P.M., President J. R. Worcester in the chair, seventy-eight members and visitors present.

The record of the last meeting was read and by vote approved.

Mr. Erasmus D. Leavitt was elected an honorary member, and Messrs. Charles F. Breitzke, Maurice F. Brown, Howard L. Coburn, Arthur W. Emerson, George F. Hobson, Arnold Seagrave, Arthur E. Tarbell, Ernest M. Trefethen and Joseph F. Wilber, members of the Society.

The President reported for the Board of Government, in the matter referred to it at the last meeting, in relation to the proposed conference in the conservation of the natural resources of the country, that it had invited Prof. George F. Swain to represent the Society at that conference so far as an opportunity presented itself and to express the approval of the Society as shown by the vote at the last meeting.

The Secretary read a communication from the Mayor of Boston calling attention to an act of the Legislature of 1907 authorizing the mayor to appoint a member of the Board of Appeal, the member so appointed to be selected from "two candidates, one to be nominated by the Boston Society of Architects and one by the Boston Society of Civil Engineers." On motion of Professor Allen, the communication was referred to the Board of Government with full power.

Prof. F. L. Kennedy, the committee appointed to prepare a memoir of our late associate, William V. Moses, submitted and read his report.

Mr. James E. Howard, civil engineer, read the paper of the evening entitled, "Some Causes which Tend Toward the Fracture of Steel Rails." The paper was illustrated by lantern slides.

The Secretary read, in the absence of its author, a discussion on the subject of the paper by Mr. J. Parker Snow. Further discussions were offered by Prof. Henry Fay, of the Massachusetts Institute of Technology; by Mr. Wm. A. Aiken, of New York, and Mr. George A. Kimball, chief engineer, and Mr. H. M. Stewart, road master, Boston Elevated Railway Company.

Adjourned.

S. E. Tinkham, *Secretary.*

Montana Society of Engineers.

Butte, Mont., May 8, 1908. — The regular meeting of the Society for the current month was held in the Society room at the appointed hour. Vice-President C. H. Bowman presided. Quorum present. Minutes of last meeting approved. Messrs. Hayes, Leggat and Hoffman were elected by the regular ballot to active membership in the Society. The Secretary was instructed to write Mr. Martin H. Gerry, Jr., and invite him to furnish the Society with a paper on the construction of the dams at Wolf Creek and at Hauser Lake. On motion, the Secretary was urged to procure an opinion from the Trustees as to the advisability of holding a midsummer meeting of the Society and present the same at the next meeting.

Adjournment.

Clinton H. Moore, *Secretary.*

Technical Society of the Pacific Coast.

Regular meeting, June 5, 1908, called to order at 8 o'clock by President George W. Dickie.

The meeting was held at the New Tortoni Restaurant, 1400 Polk Street, where the members assembled for dinner at 6 o'clock. After dinner the business of the Society was taken up.

The Secretary read the minutes of the last regular meeting, held on March 20, 1908, and upon motion the minutes of this meeting were duly approved as read.

Mr. Heinrich Homberger proposed for membership, Mr. J. W. White, mechanical engineer, care of Engineering and Maintenance Company, Fremont and Howard streets, San Francisco. It was ordered that this application take the usual course; the Secretary was instructed to communicate with Mr. White and to send him the necessary blanks.

Mr. H. D. Connick read a very exhaustive paper containing the substance of a municipal engineering report on the subject entitled, "The Auxiliary Water Supply of San Francisco." This paper proved a very interesting and important one, and on account of the lateness of the hour the President suggested that all discussion be waived and that the subject be taken up again for discussion at the next regular meeting; also, that five members be appointed, chosen from among those more particularly versed in this subject, and that these members so chosen prepare written discussions to be presented to the Society at the next regular meeting in August.

This suggestion was put into the form of a motion and unanimously carried.

The appointment of the committee of five will be taken up by the President after considering the available members for that purpose.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary*.

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